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**REVIEW OF THE FINAL REPORT
FOR THE
1991 BEACH AND NEARSHORE MONITORING PROGRAM AT
FOREST PARK BEACH, LAKE FOREST, ILLINOIS**

By

Michael J. Chrzastowski
and
C. Brian Trask

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Lake Michigan Investigations Unit
615 East Peabody Drive
Champaign, Illinois 61820-6964

March 9, 1992

Submitted to:

Illinois Department of Transportation
Division of Water Resources
Springfield, Illinois

Final Report For IDOT Project No.: WR-09118/SRA-190

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EXECUTIVE SUMMARY

1991 was the first year of a new five-year monitoring program to collect data on beach and nearshore geomorphic changes at Forest Park Beach, Lake Forest, Illinois. The 1991 data collection and presentation for the City of Lake Forest was completed by the environmental consulting firm of CH2M HILL, headquartered in Bellevue, Washington. At the request of Illinois Department of Transportation, Division of Water Resources, the Illinois State Geological Survey (ISGS) was contracted to monitor the CH2M HILL data collection, independently collect representative data for comparison, and evaluate the data presentation and discussion in the 1991 monitoring report by CH2M HILL.

Based on the ISGS study, both the survey grid established for horizontal control and the beach and nearshore wading data are considered reproducible and accurate, and are verified. Fathometer data were smoothed by CH2M HILL to eliminate boat motions caused by 1- to 2-foot waves (3 to 4 second period) at the time of the August 1991 survey. These data are considered adequate for future comparison with subsequent fathometer data with the understanding that lake-bottom irregularities across the offshore, glacial-till surface have been removed in the smoothing process.

The "bar" on the north (updrift) side of the project persists as an accretionary feature. Comparison by the ISGS of 1987 and 1991 bathymetric data results in accretion-volume estimates of 9,000 and 13,000 cubic yards for nearshore accretion north of the second breakwater from the north (Breakwater V). The larger volume estimate incorporates an area of questionable accretion due to some uncertainty in the 1987 data. These volume estimates are in general agreement with the estimated $7,000 \pm 1,800$ cubic yards by CH2M HILL (1992) and 10,000 cubic yards reported by the Lake Forest Shoreline Monitoring Committee (1990a,b). This agreement indicates that since the volume calculation by the Lake Forest Shoreline Monitoring Committee there has not been any appreciable gain in volume for nearshore accretion updrift of the project. There has apparently been accretion along the lakeward perimeter of the project. This accretion indicates that although the project may have been a total or near-total barrier in early post-construction phase, bypass is now occurring.

A previously undocumented accretion area is the northern beach cell. Comparisons between 1987 and 1991 maps and profiles across this cell indicate up to 3.5 feet of accretion in the central part of the cell and entrapment of an estimated 3,500 cubic yards of sediment. The other three cells were not examined.

The first of three years of beach nourishment on the south (downdrift) side of the project occurred on August 22 and 23, 1991 with approximately 3,000 cubic yards of coarse sand (Udden-Wentworth scale) added to the nearshore. Samples

collected and analyzed by ISGS have median particle diameters in the range 0.57-0.77 mm. This is coarser than samples collected by CH2M HILL from atop the updrift bar and in the two northern beach cells, indicating this nourishment exceeds the median diameter of the nearshore updrift accretion.

Recommendations to improve future monitoring include expansion of the fathometer data collection along the entire perimeter of the project and the reduction in extent of fathometer data collection to no more than 600 feet lakeward of the pre-construction shoreline (present profiles extend 2,000 lakeward). Documentation of erosion (or accretion) across the offshore glacial-till surface to be done by use of monitoring stakes, not comparison of fathometer profiles.

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INTRODUCTION

Forest Park Beach is a 22-acre development on the shore of Lake Michigan at Lake Forest, Illinois (figs. 1 and 2). This facility was constructed for the purpose of protecting a lakeshore park belonging to the City of Lake Forest, and enhancing recreational facilities on the city's lakeshore. Construction of Forest Park Beach began in spring 1986 and was completed by May 1987. Construction costs were paid by the City of Lake Forest.

Design, model testing and construction of the facility were by the coastal engineering firm of W.F. Baird and Associates Coastal Engineers Ltd., Ottawa, Ontario (Canada), and Warzyn Engineering Inc., Madison, Wisconsin. The Forest Park Beach facility incorporates shore-attached and offshore rubble-mound breakwaters, a rubble-mound revetment, four embayments with recreational beaches, and a protected basin with boat-launch facilities (Anglin et al., 1987). Completing the facility are access roads, parking, service buildings, walkways and landscaped areas.

Following completion of all construction at Forest Park Beach, an annual monitoring program began in 1987 to document beach and nearshore sediment and geomorphic changes. This monitoring involved collection of profile data, sediment samples and photography. After three consecutive years of monitoring, the data were assembled by a Monitoring Review Committee and a summary report was prepared by this committee for the City of Lake Forest (Lake Forest Shoreline Monitoring Committee, 1990a,b).

The permits for the Forest Park Beach project issued by Illinois Department of Transportation Division of Water Resources and Chicago District Corps of Engineers required that the City of Lake Forest comply with the recommendations of the Review Committee as outlined in their final report. One of these recommendations was that annual monitoring continue for an additional period of five years.

The first year of this new monitoring program was 1991. For the collection of all 1991 survey data, the City of Lake Forest contracted the firm of CH2M HILL headquartered in Bellevue, Washington. CH2M HILL designed a surveying and sampling plan in early summer 1991, conducted data collection in late summer and early fall 1991, and presented a two-volume document to the City of Lake Forest in February 1992. Volume 1 is the technical document with data presentation; Volume 2 is a collection of 1991 aerial and ground photography. The technical document is titled: *1991 Shoreline Monitoring of Forest Park Beach, Lake Forest, Illinois, Volume 1*. A complete citation is given in the REFERENCES.

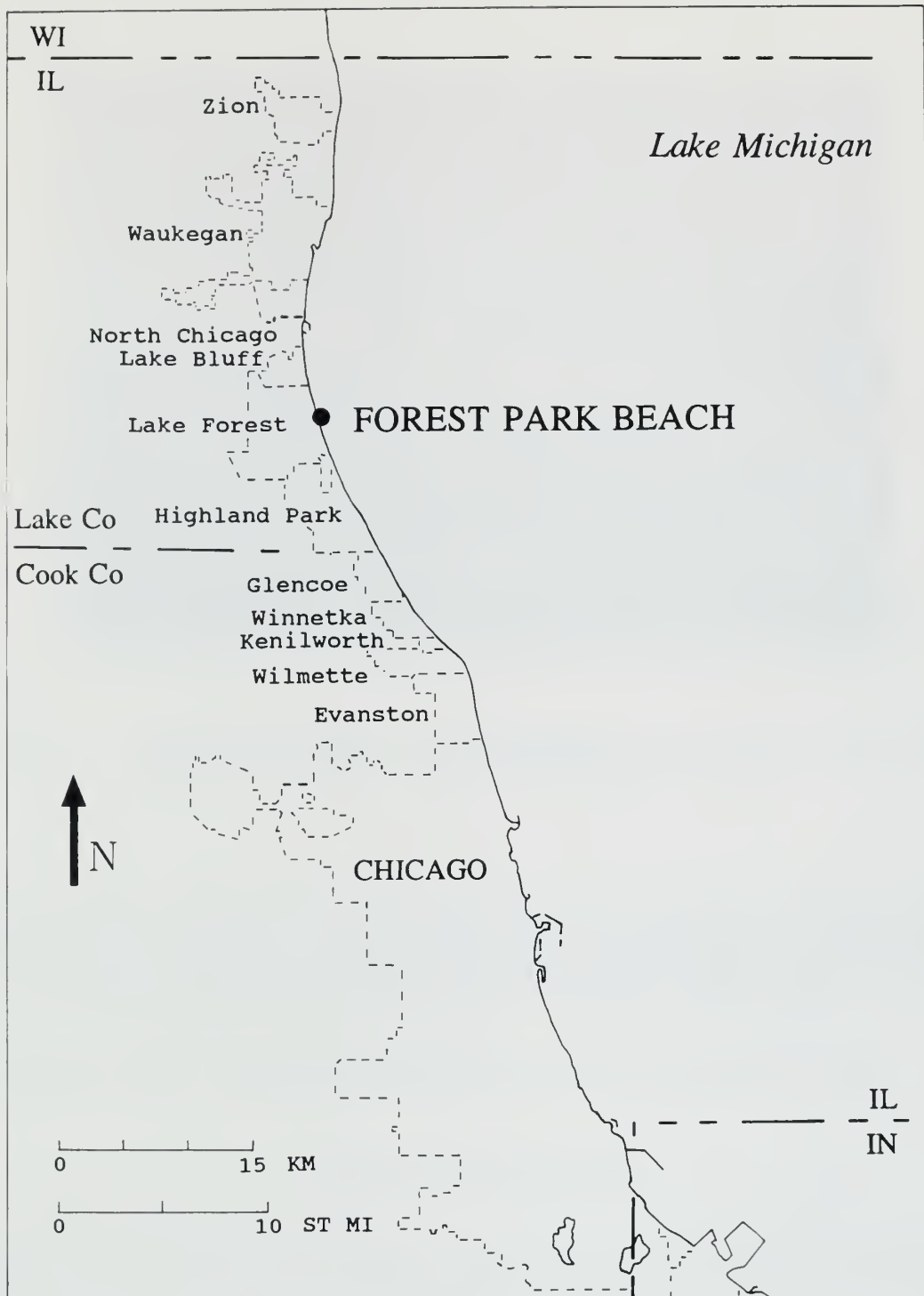


Figure 1. Map of the Illinois shore of Lake Michigan showing location of Forest Park Beach.



Figure 2. Low-altitude oblique aerial photograph of Forest Park Beach viewed from the northeast. Photo date: August 14, 1991.

This report is a review of the data collected and an evaluation of the final report prepared by CH2M HILL. It was prepared by the Illinois State Geological Survey for the Illinois Department of Transportation, Division of Water Resources and is the final product required for IDOT Project No. WR-09118/SRA-190.

This report neither supplements nor supersedes the CH2M HILL report.

PURPOSE AND SCOPE

The Illinois Department of Transportation (IDOT) Division of Water Resources (DWR) is responsible for regulatory functions along the nearshore and offshore zone of the Illinois coast of Lake Michigan. As part of its program to assure proper coastal management and mitigation, IDOT-DWR has specific interest in the quality assurance and quality control of the coastal monitoring program at Forest Park Beach. Early in 1991, IDOT-DWR contracted the Illinois State Geological Survey (ISGS) to provide an independent review of the 1991 monitoring program and final report and to independently collect data for comparison with the data

collected by the city's consultant. The ISGS has a history of several decades of geologic study along the Illinois coast.

The key aspects of this review and the role of ISGS were:

- 1) Observe and document the data collection procedures used by the city's consultant and independently repeat 10% of the consultant's survey lines for data comparison and check.
- 2) Independently review the adequacy and reproducibility of the consultant's data and the annual monitoring report prepared by the consultant and summarize this review in a report to IDOT-DWR.
- 3) Summarize interpretations by the ISGS regarding coastal processes at Forest Park Beach and local and regional littoral transport processes.
- 4) Incorporate and archive all data collected by the ISGS into the existing ISGS database on Illinois lakeshore coastal geology.

PART 1: DATA COLLECTION AND PRESENTATION

ISGS FIELD PROCEDURES

Fathometer Surveys (Long Profiles)

ISGS lake-bottom profiling by fathometer involved a three-person team consisting of two persons in a survey boat and one person onshore. The boat was a 12.5-foot "Zodiac-type" inflatable with a 9.9 horsepower outboard motor. The onboard fathometer was a Ross Model 803 Portable Survey Fathometer with a 100 kiloHertz transducer. The transducer was mounted over the port side of the boat with the transducer positioned 0.5 feet below water level. Correcting for the transducer depth is not necessary in reading the fathometer traces because the Ross Model 803 fathometer has an adjustment that compensates for this depth. At the beginning of the survey, the fathometer was calibrated by lowering a steel grate below the transducer and receiving a fathometer record at one-foot intervals from 2 to 12 feet (also known as a "bar check"). Calibration was also verified by comparison with a stadia rod.

Position control for the fathometer surveys involved a range/azimuth technique. The onshore field assistant used a standard surveyor's transit positioned over the control point for the profile line that had been marked and surveyed by the consultant. The transit was oriented along the azimuth of the profile line. As the survey boat advanced toward shore, the transit operator gave radio instructions and/or visual signals to the boat operator to keep the boat within one boat width (5.6 feet) of the profile line (*i.e.*, the transit center line). Approximate boat speed during the profiling ranged from two to three knots (3 to 5 feet/sec).

Offshore distance to the survey boat was measured using a Motorola Mini-Ranger III system. The Mini-Ranger measures distance in meters by the travel time of a microwave signal between a transceiver and transponder. The transceiver and console were aboard the survey boat; the transponder was onshore placed beneath the transit at the profile control point. The fathometer operator monitored the digital display of distance on the Mini-Ranger console, and made an event mark on the fathometer trace at every 33-foot (10-meter) interval. For reference, at every 164-foot (50-meter) interval a bolder mark was made by a slightly longer depression of the event button. Profile start time was noted for later water-level corrections. Profiles began offshore at a distance of 2625 to 2950 feet (800-900 meters) and continued toward shore to a water depth of about two feet. In order to form a continuous profile, beach and nearshore profiling (short lines) were done as a continuation and overlap for each of the fathometer (long) lines.

The manufacturer states the accuracy of the Mini-Ranger III system are plus or minus 10 feet (3.0-meters) at maximum range. The system has a maximum range of 22 miles (37 kilometers). The Mini-Ranger used in this study was capable of

operating to a minimum distance of 33 feet (10 meters) between the transponder and transceiver.

Although the ISGS was only required to repeat 10% of the consultant's fathometer profiles, the time invested in field mobilization and the total number of lines made it advantageous for ISGS to increase the number of lines surveyed. CH2M HILL ran a total of 15 fathometer lines; the ISGS repeated 9 of these lines (60%). Figure 3 shows the plan and designation of the fathometer profiles.

Beach and Nearshore Wading Surveys (Short Profiles)

The onshore and nearshore wading surveys were conducted by one person using a total station surveying transit positioned at one of the bench marks in the project area and another person with prism pole advancing in increments along the profile line. The total station was a Lietz/Sokkisha Set 3 with a Lietz/Sokkisha SDR2 Electronic Field Book. All position and elevation data were recorded in the electronic notebook. The person with prism pole maintained position along the profile line by sight alignment of onshore stakes and/or flags. Elevation measurements were normally made at intervals of approximately 5 to 15 feet. Smaller intervals were used to document notable changes in relief and bottom texture. Longer intervals were used in areas with relatively continuous slope. The profiling was extended offshore to about a 10-foot water depth by swimming. A wet suit allowed for prolonged stays in the water.

Figure 4 shows the plan and designation for the total of 41 beach and nearshore wading profiles surveyed by CH2M HILL. Because of their short length relative to the fathometer lines, these beach and nearshore profiles are referred to in the CH2M HILL report and this report as the "short" profiles. The ISGS repeated 8 of the 41 short profiles (19.5%), selecting two lines from each of the four beach cells.

Field Schedule

The ISGS collected 1991 profile data at Forest Park Beach by fathometer and wading on two separate occasions. Fathometer data were first collected on August 12, which corresponded to the first day of the two days the consultant collected fathometer data. On the following two days, August 13 and 14, both the ISGS and the consultant collected profile data by total station surveying instrument and prism pole. The second ISGS occasion for data collection by the ISGS involved fathometer profiling on October 09, and beach and nearshore prism-pole profiling on October 10. These dates were selected because the lake was especially calm at the time.

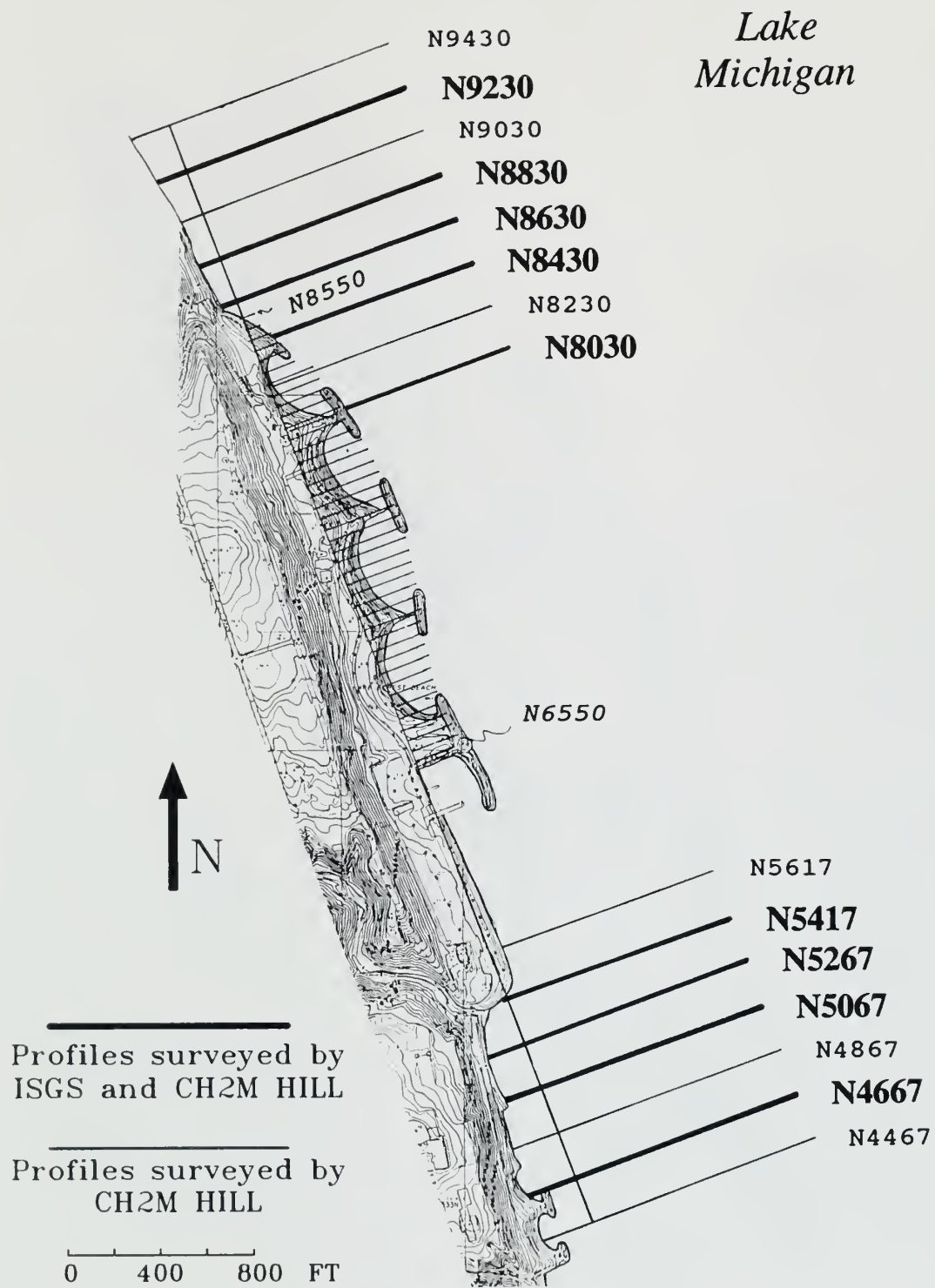


Figure 3. Location and designation of fathometer (long) profile lines.

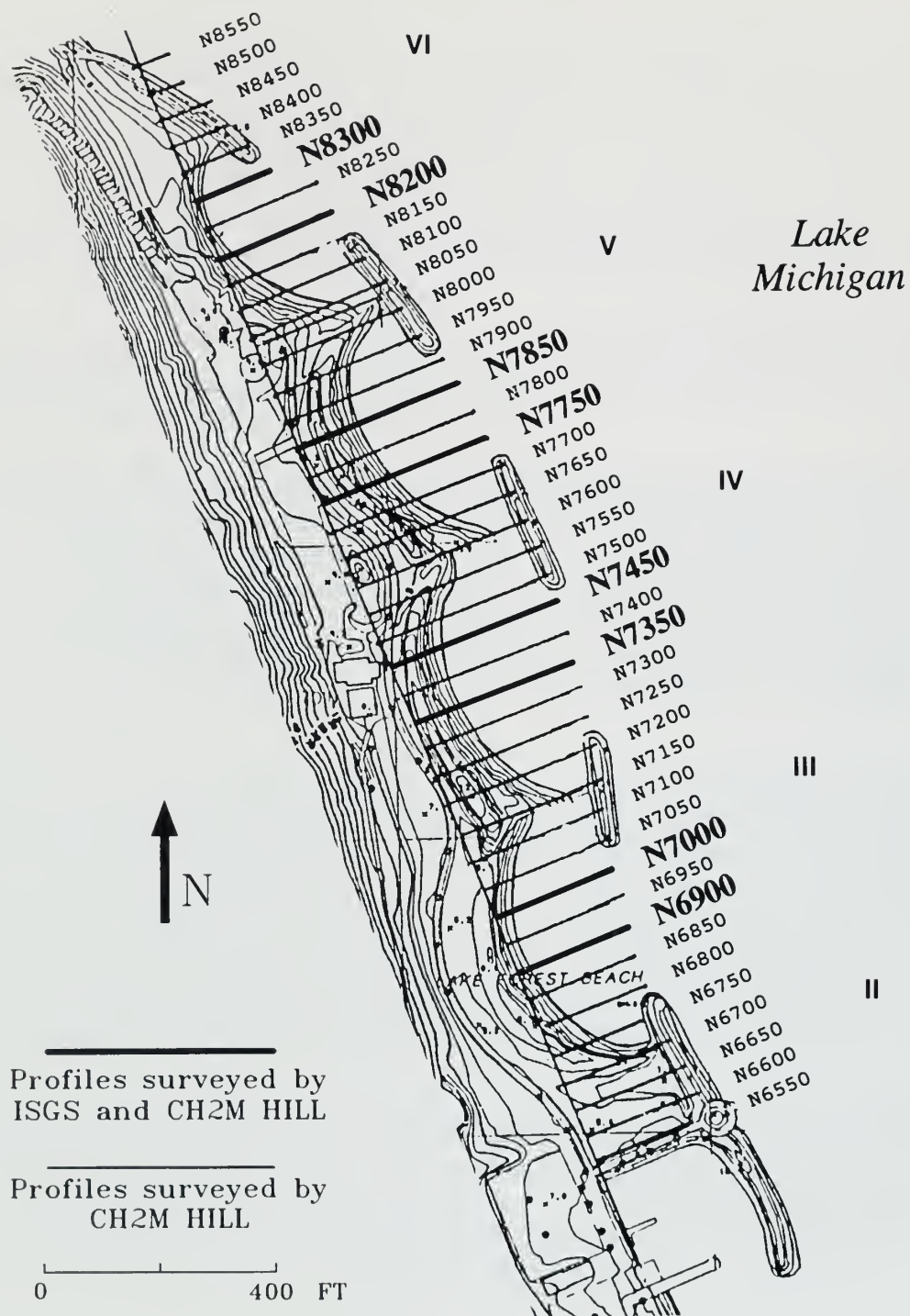


Figure 4. Location and designation of wading (short) profile lines. Roman numerals are breakwater designations.

ISGS DATA PROCESSING

Depths on the fathometer traces were tabulated at every 16 feet (5 meters). Additional depth/distance points were interpolated for prominent features occurring between the 16-foot increments. Fathometer traces for August 12 required visual smoothing to filter the effects of approximately two-foot waves. This smooth line was drawn midway within the sawtooth pattern of peaks and troughs. The fathometer traces from October 09 were read directly, because the data were collected during calm water and no wave-height correction was needed. Photo-reduced reproductions of these fathometer traces are included in APPENDIX A.

The Mini-Ranger distances were referenced to the coordinates of the profile control point and converted to both Illinois state plane coordinates and the local coordinates of the CH2M HILL survey grid.

All depths were first corrected to Lakes Michigan-Huron Low Water Datum (LWD). This correction involved a depth adjustment based on the average of hourly lake levels recorded by the National Ocean Service at both Calumet Harbor, Illinois (Gauge No. 7044) and Milwaukee, Wisconsin (Gauge No. 7057). The profile data collected by wading were direct measurements of lake-bottom elevations and did not require correction for lake level or wave action. The depths were subsequently adjusted to Lake Forest Datum (LFD) for the preparation of all profiles and bathymetric maps.

Tables 1 and 2 show hourly Calumet Harbor and Milwaukee lake-level elevations for the fathometer survey dates in August and October. The hourly average LFD is the correction factor subtracted from the raw depth data to reduce depths to LFD. For both dates during the hours of fathometer operations there was excellent agreement in lake level at the Calumet and Milwaukee gauges with only one reading (October 09; 1400 hrs) having a difference slightly exceeding 0.1 feet. The overall agreement attests to a lack of any lake level set-up, seiches, or regional fluctuations along this segment of the western lakeshore at the time of the surveys.

The X-Y-Z data of position and LFD-corrected depth were plotted as profiles using the ARC/INFO Geographic Information System (GIS) system. The profiles were drawn to the same scale, format and vertical exaggeration (10x) as done in the CH2M HILL report to facilitate comparisons. The fathometer (long) profiles with their beach/nearshore wading components are assembled in APPENDIX B. The wading (short) profiles are assembled in APPENDIX C.

Table 1. August 12, 1991 hourly Calumet Harbor and Milwaukee lake-level elevations in feet above Low Water Datum (LWD) and Lake Forest Datum (LFD), and average elevation used in adjusting depths to LWD and LFD.

12 AUGUST 1991							
HRS CST	Calumet Harbor Illinois		Milwaukee, Wisconsin		Calumet/ Milwauk. Lake Level Diff.	Mean Corr. to LWD	Mean Corr. to LFD
	LWD	LFD	LWD	LFD			
1300	2.25	0.19	2.27	0.21	0.02	2.26	0.20
1400	2.27	0.21	2.32	0.26	0.05	2.30	0.24
1500	2.32	0.26	2.40	0.34	0.08	2.36	0.30
1600	2.22	0.16	2.22	0.16	0.00	2.22	0.16
1700	2.19	0.13	2.23	0.17	0.04	2.21	0.15
1800	2.29	0.23	2.21	0.15	0.08	2.25	0.19

Table 2. October 09, 1991 hourly Calumet Harbor and Milwaukee lake-level elevations in feet above Low Water Datum (LWD) and Lake Forest Datum (LFD), and average elevations used in adjusting depths to LWD and LFD.

09 OCTOBER 1991							
HRS CST	Calumet Harbor Illinois		Milwaukee, Wisconsin		Calumet/ Milwauk. Lake Level Diff.	Mean Corr. to LWD	Mean Corr. to LFD
	LWD	LFD	LWD	LFD			
0800	1.39	-0.67	1.46	-0.60	0.07	1.43	-0.64
0900	1.38	-0.68	1.33	-0.73	0.05	1.36	-0.71
1000	1.37	-0.69	1.37	-0.69	0.00	1.37	-0.69
(No fathometer surveys between 1030 and 1330)							
1400	1.57	-0.49	1.44	-0.62	0.13	1.51	-0.56
1500	1.39	-0.67	1.44	-0.62	0.05	1.42	-0.65
1600	1.32	-0.74	1.30	-0.76	0.02	1.31	-0.75
1700	1.26	-0.80	1.28	-0.78	0.02	1.27	-0.79

REVIEW OF THE CH2M HILL FIELD PROCEDURES AND SURVEY GRID

During the August 1991 survey, the ISGS monitored CH2M HILL field procedures and operations. The operations monitored included installation of a water-level gauge, establishing horizontal control points onshore along the profile lines, and conducting beach, nearshore and offshore profiling. CH2M HILL followed all standard field procedures for such a survey. All survey equipment was modern and in excellent repair.

The survey control grid established by CH2M HILL was independently verified by ISGS. For all the stakes and temporary bench marks along profile lines occupied by ISGS, the X,Y,Z coordinates determined by CH2M HILL were replicated by the ISGS.

In the CH2M HILL report, the cover sheet to APPENDIX B (Tabulated X,Y,Z Coordinates) gives conversions and rotation angles for making transition from local to state plane coordinates. These conversions and rotations were checked and verified.

COMPARISON OF ISGS AND CH2M HILL FATHOMETER (LONG) PROFILES

When comparing fathometer profiles by ISGS with those of CH2M HILL, it is important to emphasize that different techniques were used in both position control and the collection and processing of fathometer data. There are advantages in making comparisons between data collected using different techniques because this can demonstrate that data trends are independent of equipment and/or procedures.

In this study, the accuracy of the two methods for position control is not equivalent, and this inequality may lead to differences in the profile comparisons. CH2M HILL used the **Hydro 1**, a fully automated range-azimuth survey system (International Measurement and Control Company, Littleton, Colorado). This is a state-of-the-art system for nearshore hydrographic surveying that electronically links position data and digital fathometer data. The accuracy of this position control is ± 2 feet (0.6m). Position control by the Mini-Ranger III system used by ISGS is ± 9.8 feet (3m). The ISGS profiles provide a check of overall trends. Site-specific depth comparisons are limited by the differences in equipment accuracy.

Differences in data processing also are important to note. To eliminate boat motions from the August 1991 fathometer surveys, CH2M HILL processed the digital fathometer data by performing a recursive 11-point running-average technique; ISGS did a visual smoothing of the fathometer trace. ISGS also

collected a second set of fathometer traces during calm water that required no special processing.

The three purposes of the fathometer (long) profile comparisons were to: 1) compare the ISGS profiles from August and October to determine how well the visual smoothing compared with calm-water profiles collected by identical technique; 2) compare the CH2M HILL profiles and the ISGS October profiles to evaluate the adequacy and limitations of the CH2M HILL smoothing of the August data; and 3) evaluate the reproducibility of the CH2M HILL profiles. The two data sets of ISGS fathometer profiles (August and October) and their comparison with the CH2M HILL profiles are shown in APPENDIX B.

The ISGS long profiles assembled in APPENDIX B include the wading component on the landward end and show the overlap and agreement of these two data sets. The minimum overlap is about 50 feet; the overlaps are generally about 100 feet. An exception is on the lakeward edge of breakwaters where a break in the profile occurs because of the inability to take the prism pole farther lakeward.

In general, the fathometer and wading profiles superimpose or show close agreement. In some cases the ISGS wading profiles are at lower elevation, but this is a recognized problem explained by equipment limitations, particularly on the lakeward parts of these profiles, and is discussed in a subsequent section. The CH2M HILL short profiles do not graphically portray the overlap indicating the variance of the fathometer and wading components, but all the CH2M HILL long profiles had such overlap and no data gaps occur.

Comparison of the ISGS August and October profiles shows that the visual smoothing procedure eliminated many irregularities across the glacial-till surface. However, there is agreement in the overall profile geometries. Major undulations across the glacial-till surface recorded in October are represented on the smooth version for August. Undulations recorded in October but not present in August could be a factor of the smoothing, but could also be due to slight differences in boat position over this irregular bottom. The October fathometer trace was collected at a time of mirror-like lake conditions, and thus the traces show actual irregularities across the glacial-till surface. An irregular offshore bottom has been documented in fathometer profiles collected off Forest Park in the 1940's and 1950's (Illinois Division of Waterways, 1958), in the first monitoring program at Forest Park Beach (Lake Forest Shoreline Monitoring Committee, 1990a,b), and in recent bathymetric surveys near Fort Sheridan by the U. S. Geological Survey (Booth, 1990).

The ISGS August and October profiles provide a record of lake bottom changes over this two month interval. On profile N8430 up to one foot of sediment was apparently removed from near the toe of the breakwater. This likely represents the intermittent gain and loss of sediment along this bypass accretionary prism as the

prism adjusts to wave energy and sediment budget. On the south side of the project, comparison of the August 12 and October 09 profiles shows lake-bottom changes attributable to the sediment influx and dispersion from beach nourishment that occurred on August 22 and 23. Profiles N5417 and N5067 record accretion across the shoreface, and profile N4667 records accretion at the breakwater toe.

Comparing the CH2M HILL profiles and the ISGS August and October profiles, it is clear that the smoothing by CH2M HILL has eliminated irregularities on the offshore, glacial-till lake bottom, but there is overall agreement in profile geometries. Along several profile lines, there is very good agreement among the three profiles. For example, along profiles N8430 and N8830 the three profiles are in agreement within one foot or less. This is considered good agreement for this particular data set considering the differences in data collection and data processing methods, and the inherent problems of replicating profiles across this irregular surface.

The greatest discrepancy in the profile comparisons occurs on profile N4667. Lakeward of local easting 2350, the CH2M HILL profile has higher elevation than either the ISGS August or October profiles. The difference, as much as 2.5 feet, could be caused by a discrepancy in water-level corrections or could be a result of the smoothing procedure used by CH2M HILL. Agreement of the ISGS August and October profiles gives preference to the mean elevations of these profiles, and it is recommended that any future lake-bottom comparisons on the offshore part of profile N4667 use the ISGS data from 1991. Repeating fathometer (long) profile (N4667 in the 1992 annual survey is warranted to further examine what may have caused discrepancy in the data collection.

Differences in the density of data points on the wading part of the long profiles results in a profile difference on line N8030. The ISGS identified a depression on the landward side of the breakwater (Breakwater V). This depression or hole is not shown on the CH2M HILL profile. The depression was recorded in the ISGS August and October surveys, but was shallower in October. The maximum depth recorded in August was 4 feet LFD. Figure 5 shows an ISGS surveyor with prism pole standing in this depression. This feature may result from lakeward loss of sand from the cell through the porous breakwater. Continued monitoring of this depression is warranted. More subtle depressions occur on the landward side of the northernmost breakwater (fig. 6).

Comparison of ISGS and CH2M HILL fathometer (long) profiles verifies the reproducibility of the CH2M HILL data. The smoothing by CH2M HILL has produced generalized profiles across the offshore, glacial-till surface, but these profiles are not different in overall from those that produced during calm water. The nearshore parts of the CH2M HILL profiles have had the minimum degree of



Figure 5. Member of ISGS survey team with prism pole measuring elevation in the depression on the landward side of the breakwater of Profile N8030. Photo date: August 13, 1991.



Figure 6. View of beach depression on landward side of north breakwater. Photo date: August 14, 1991.

smoothing because the smoothing procedure was run from landward to lakeward. Good agreement occurs along these nearshore parts of the profiles between the calm-water data collected by the ISGS in October, and the smoothed CH2M HILL data. This agreement indicates that the CH2M HILL profiles can be used as 1991 baseline data for monitoring lake-bottom changes in the nearshore zone where the fathometer profiles have their greatest application.

COMPARISON OF ISGS AND CH2M HILL WADING (SHORT) PROFILES

The ISGS and CH2M HILL used identical survey procedures for the short profiles. This involved one person operating the surveying instrument at a control point, and a second person advancing along the profile with a prism pole. The objective in ISGS reoccupying these short profiles was to check reproducibility of the CH2M HILL data.

Within each of the four beach cells, ISGS occupied two short profiles spaced 100 feet apart in the center of the cell and extending lakeward between the breakwaters (fig. 4). The ISGS short profiles and their comparison with the CH2M HILL profiles are presented in APPENDIX C.

Slight differences in elevation between the ISGS and CH2M HILL profiles occur in the more lakeward parts of the profiles. Typically the ISGS profiles indicate lower elevations as shown on Profiles N7750, N7000, and N6900. The lower elevations in the ISGS data are attributed to the ISGS prism pole sinking into the fine-grained bottom sediments. While surveying in shallow water, the swimmer attempted to keep the rod from penetrating into the sand by standing on the sand and holding the rod at a neutral position in contact with the surface. However, as the water depth became too great for wading, the rod was used as an anchor to keep on station. Consequently the rod penetrated into the sand. This was particularly true during the rough-water conditions of the August survey. CH2M HILL had a larger diameter pole that presumably had less tendency to sink into the sediment. Thus, the CH2M Hill data are considered a more accurate depiction of elevations along the lakeward parts of these short profiles.

Excellent agreement occurs in the comparison of some lines, such as profile N7850. Profile differences occur on the edge of breakwaters, as in profile N7450, but this can be explained by points shot at different elevations and different rod positions atop the breakwater riprap. The only major discrepancy between the data sets occurs on profile N8300 at a local easting of approximately 2100 feet. The ISGS data define a high point as a distinct "spike", but the CH2M HILL profile depicts a gentle lake-bottom slope to either side of this high. The difference reflects a greater density of points on the ISGS line. The feature is apparently a large rock associated with the north breakwater (Breakwater VI).

In comparing the CH2M HILL tabulated points for the wading (short) profiles with the graphic presentation, several profiles have problems that need to be recognized in future comparisons. Profiles N8500 and N8250 will require an approximate 2-foot datum adjustment to lower the profile elevation. Other CH2M HILL wading (short) profiles have an elevation discrepancy between how the last two to four data points are tabulated and how they are graphically displayed. These profiles are: N8450; N8150; N8050; N7900; N7700; N7250; N7000; and N6800.

The replication of elevations along most of the length of the CH2M HILL short profiles, combined with the ability to explain anomalous data on the lakeward ends of several of the ISGS short profiles, are the basis for verifying the CH2M HILL beach and nearshore (short) profiles as reproducible and accurate.

AREAL AND VOLUMETRIC CHARACTERISTICS OF THE UPDRIFT ACCRETION

Preparation of a 1987 Base Map

Bathymetric data collected June 04, 1987 by Warzyn Engineering, Inc. (WEI), along their profiles 26 through 34 were used to construct a base map of bathymetric conditions at Forest Park Beach north of the northern two breakwaters (Breakwaters V and VI).

A problem with these profiles is some uncertainty with the corrections used in the adjustment to Lake Forest Datum (LFD). An additional problem is that the original bathymetric profiles were not available and thus it was necessary to work with photocopies. When the photocopies were made, the originals had been reduced to permit three strips of profiles to fit on one 11 inch x 17 inch piece of paper, often obscuring the zero line. For ease in working with these profiles, and to minimize geometric error due to estimating depth on the small-scale charts, the profiles were enlarged 200 percent by photocopying. The depth at each 100-foot interval (marked on the profile) was determined by measuring from the WEI drawings of the profiles. Using these depths to set up a scale relative to a fixed line on the profiles, it was possible to digitize the 1987 profiles at depth intervals of one-half foot.

To check the validity of the resulting dataset, all profiles were plotted at the same scale (1:480, 10x vertical exaggeration) as the WEI drawings and compared to those drawings by overlaying on a light table. Where good fit was not observed at the Warzyn-selected datum points, the profile was redigitized. Some misfit was allowed because a line had been drawn through the fathometer record by WEI to smooth wave-induced boat motions. Sometimes this line was drawn at the base of the wave-induced irregularities. This makes the bottom appear to be lower in elevation than it actually was at the time of survey, because disturbance

of the water surface by waves is equally distributed about the mean water level. To correct for this error, the smooth line was redrawn through the profiles at the mean water level. Also, because of the irregular topography across the offshore glacial till, the line was adjusted to eliminate smoothing of the bottom.

In order to plot the bathymetric data from the WEI 1987 profiles onto the Lake Forest base map, the profile lines had to be transferred to the digital base map provided by the City of Lake Forest. Blue-line copies of the aerial photographs and line drawings from Warzyn Engineering, Inc. (1986) were obtained from the City of Lake Forest. These maps contained both the location of the origin of each profile and the profile line itself. The photos/drawings were updated in 1988 to include the location of profile lines actually run in 1987 and 1988. Information for WEI profiles 26 through 34 were digitized and transferred to the base map.

The production of a digital base map from the 1986 study, as revised, presented a challenge because the grids used on the WEI maps and engineering drawings were local survey grids with no known relationship to other grids. Also, the grid on the aerial photographs did not correspond to the grid on the drawings and could not be used to correlate the two different media.

Digitizing of the WEI profile lines was done in two parts, both registered to the digital coverage obtained from the City of Lake Forest. Locations of the northern profile lines (profiles 30 to 34) were obtained from WEI Sheet 12, which is an aerial photograph with a superimposed topographic map. Registration points were selected on the eastern ends of groins and corners of buildings based on their rectified (mapped) positions rather than their photographic positions, which could not be used because of the extreme distortion caused by the difference in relief between the top of the coastal bluffs and the lakeshore. Corresponding points were added to the digital map of Lake Forest to register the sheet, and the profile lines and their control points were digitized.

Locations of the southern profile lines (profiles 26 to 29) were obtained from WEI Sheets 10 and 11, which are engineering drawings with superimposed topographic maps. Sheet 11 could not be registered accurately to the base map because of its lack of identifiable points. On sheet 10, registration points were selected at the western ends of the groins attached to the northern two breakwaters and at points on the road along the top of the bluff. Corresponding ticks were added to the digital map of Lake Forest. Sheet 11 was then overlaid on Sheet 10, and the two were taped together for registration. Profile lines and their control points were digitized, and the resulting cover was combined with that depicting the northern profile locations.

Preparation of 1987 Bathymetric Maps

Bathymetric data obtained from the photocopies were plotted along the profile lines on the Forest Park Beach base map and hand contoured. WEI profile 33 was not used because it was not surveyed in 1987. The resulting bathymetric map has shore-parallel depth contours with steeper gradients within 100 to 150 feet of the shoreline (fig. 7). Lesser gradient farther lakeward is developed mainly on the glacial-till lake bottom. Irregularities on this part of the map reflect the hummocky nature of the glacial till. This surface is likely more irregular than shown, but could not be contoured in sufficient detail to reveal the many isolated highs and closed depressions that may be present. A noteworthy characteristic of this map is the lack of any longshore bars in the nearshore.

Profile 31 on Figure 7 is anomalous in that it requires a lakeward displacement of the bathymetric contours. Because of this, the WEI 1987 data were recontoured omitting WEI profile 31. The resulting map (fig. 8) eliminates lakeward projection of the bathymetry at WEI profile 31, but otherwise does not significantly change the map. On both maps the steeper nearshore is truncated by the Forest Park Beach project, illustrating the original continuation of this bathymetry along the nearshore now beneath the northern end of the project.

Preparation of 1991 Bathymetric Maps

ISGS long profiles N8030, N8430, N8830, and N9230 and their nearshore wading components, and ISGS short profiles N8200 and N8300, were used to map bathymetry from the ISGS August 1991 survey (fig. 9). The apparent bar at a depth of 12 to 12.5 feet is due to wide spacing (400 feet) between profile lines. This resulted in connecting unrelated isolated highs on the glacial-till surface. A small bar occurs at the north end of the map area at a depth of 4.5 to 5 feet; no major bars occur.

Comparing the August 1991 bathymetry with the bathymetry from the 1987 WEI surveys reveals a more gradual slope in 1991 along the northern breakwater and a lakeward translation of the 5- and 10-foot contours along both breakwaters. This results from accretion along the breakwaters that has increased the elevation of the lake bottom without forming a bar. Accretion is also recorded in the northern beach cell, where the 5-foot contour has translated lakeward from near the post-construction shoreline to near the breakwaters.

Because the August 1991 fathometer data are smoothed, data obtained by ISGS during October 1991 were used to contour the bathymetry in the same area. In addition to the profiles used for the August 1991 map, the October 1991 map also used ISGS data from long profile N8630, located just north of the base of the northern breakwater. Data from ISGS short profiles N8200 and N8300 were not



Figure 7. 1987 bathymetry of the updrift accretion area contoured by ISGS from profile data collected by Warzyn Engineering, Inc. (WEI).



Figure 8. Alternate 1987 bathymetry of the updrift accretion area contoured by ISGS from profile data collected by Warzyn Engineering, Inc. (WEI), without use of WEI profile 31.

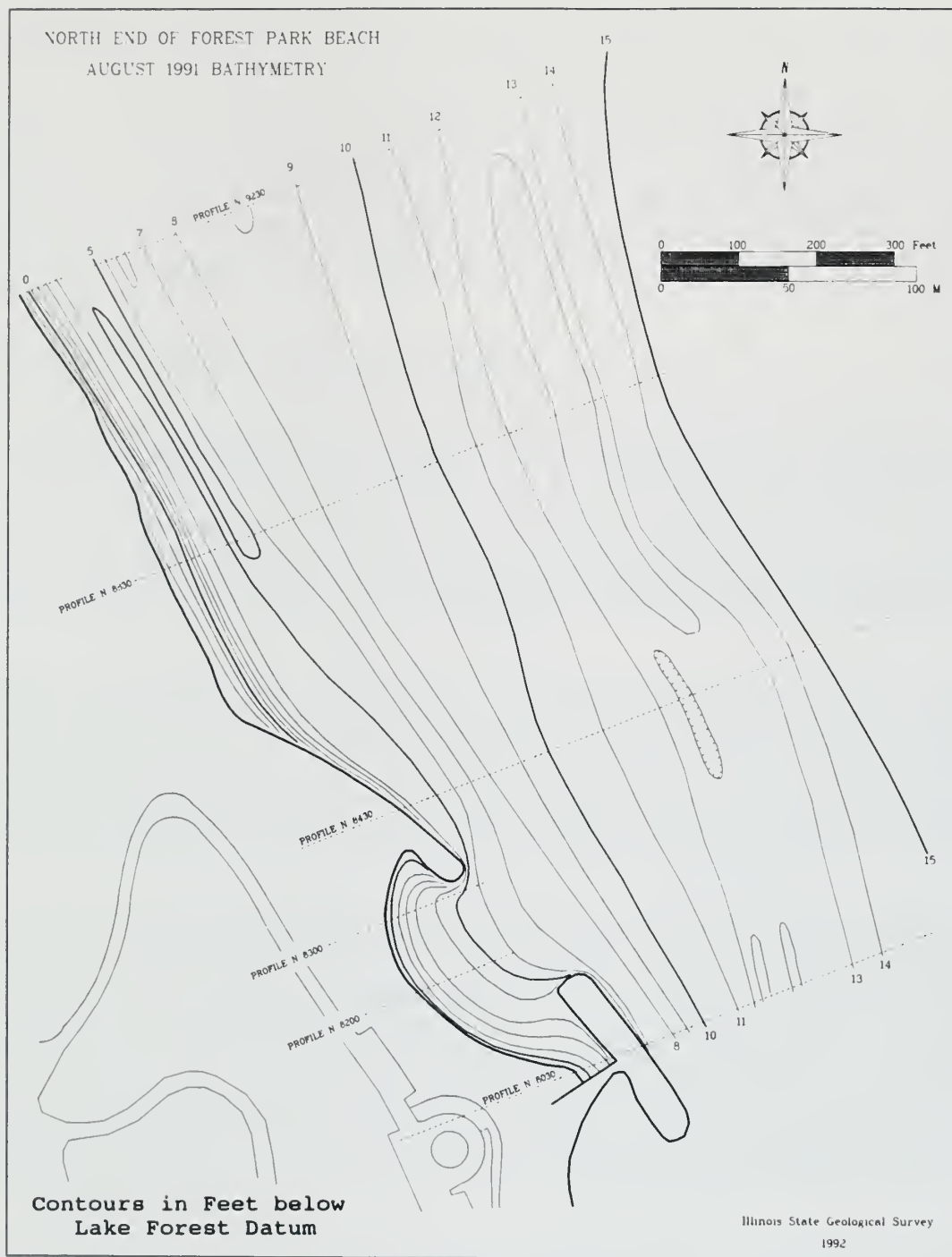


Figure 9. August 1991 ISGS bathymetry of the updrift accretion area.

available since these lines were not surveyed in October. The resulting map (fig. 10) is similar in appearance to the August map. The small bar at the northern end of the map area is still present. The lakeward progression of the 5- and 10-foot contours along the breakwaters is similar. The offshore area is dissimilar only in that the lake-bottom highs and lows are contoured in a slightly different fashion. This is a result of differences in the smoothed and calm-water data, possible slight variances in the survey-boat position between August and October, and the difficulty in mapping highly irregular bathymetry of the glacial-till bottom using widely spaced profile lines.

Lake-bottom Areal and Volumetric Change

To determine the areal distribution and volume of updrift accretion that took place in the nearshore between 1987 (WEI) and 1991 (ISGS), maps for the two years were overlain and the difference between maps calculated where contour lines crossed. Because the purpose of this exercise was to compare accretion volume estimates presented in the CH2M HILL report, only the ISGS bathymetric map for August 1991 was used (fig. 9). This eliminates uncertainties about possible lake-bottom changes between August and October.

Figure 11 shows contoured lake-bottom changes derived from comparison of the WEI 1987 and ISGS August 1991 bathymetric (*i.e.*, comparison of figures 7 and 9). A broad area of shore-perpendicular erosion occurs centered on WEI profile 31. The shore-perpendicular erosional pattern is anomalous, and inconsistent with local coastal sedimentary processes. The apparent erosion is believed to be a result of problems with the data or location of 1987 WEI profile 31.

The 1991 map was compared in a similar manner with the 1987 bathymetric map contoured without the data from WEI profile 31 (*i.e.*, comparison of figures 8 and 9). The resulting lake-bottom change map, shown in Figure 12, is similar in overall appearance to the previous erosion/accretion map, but the amount of erosion indicated at the northern end of the map area is significantly less. It is unknown whether the erosion depicted across this area is real or a result of errors in locating 1987 WEI profiles 30 and 32 or in obtaining data from the profiles. The important observation is that the distribution and extent of accretion areas are essentially the same.

Bypassing or entrapment of sand at the Forest Park Beach must be considered a process with all parts interrelated and all parts comprising the littoral transport system. Thus, any distinctions among accretion areas or zones is purely arbitrary. However, examination of the lake-bottom change map (fig. 12) shows accretion patterns related to the breakwaters that allows delineation of three accretionary areas that can be considered individually. For discussion purposes, these areas

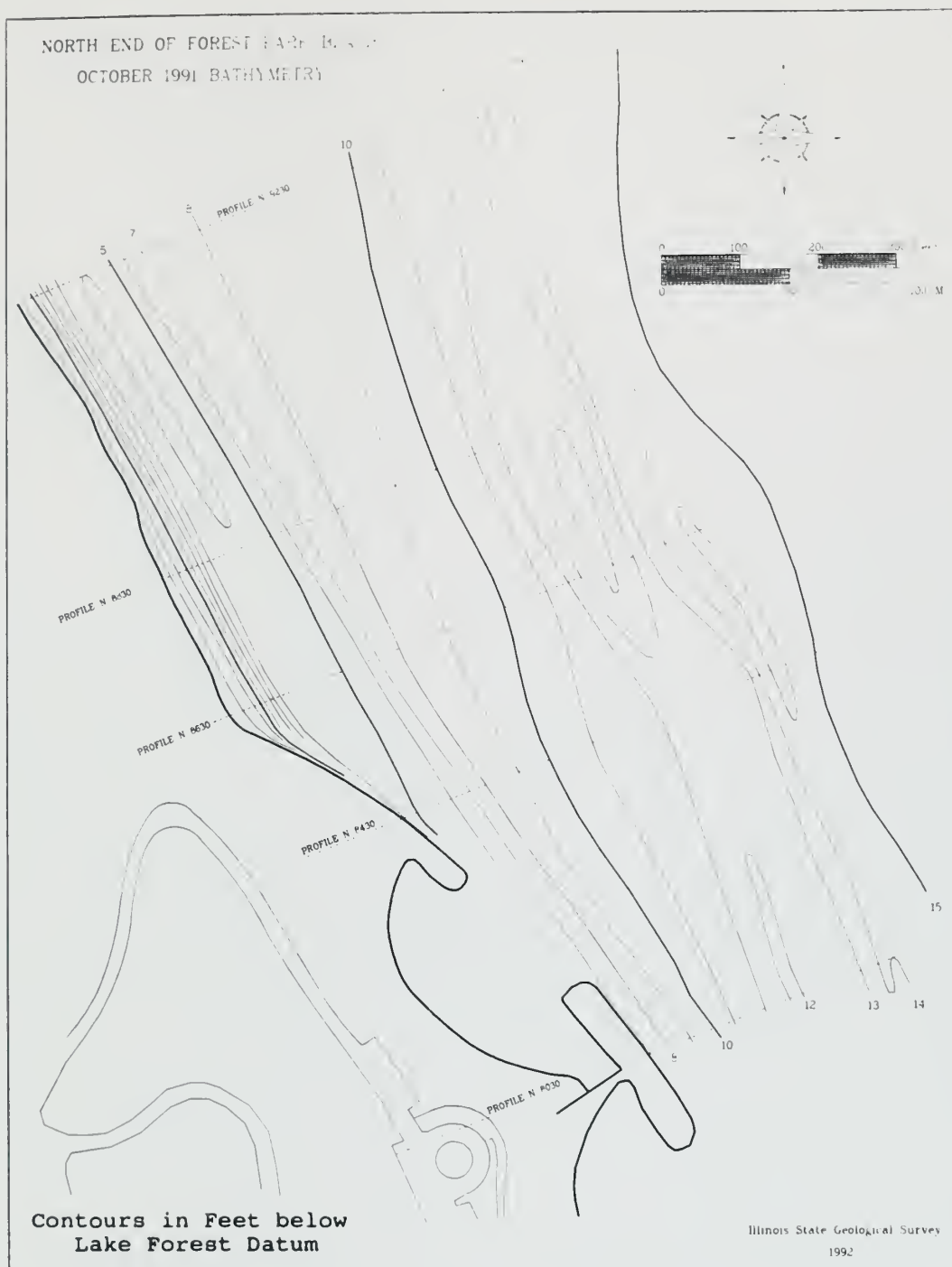


Figure 10. October 1991 ISGS bathymetry of the updrift accretion area. Because profile data were not collected from the beach cells in October, no contouring was performed in the northern cell.

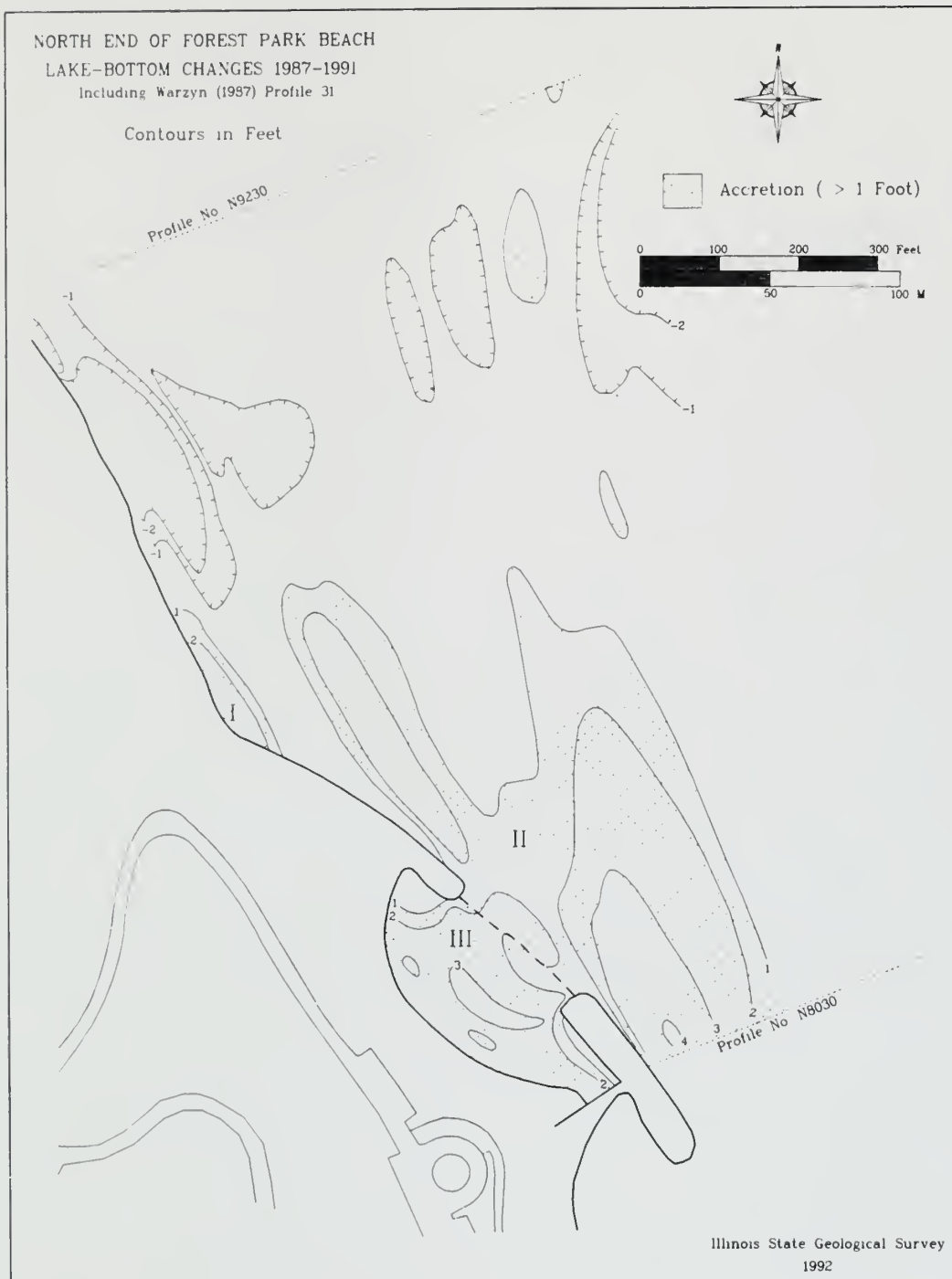


Figure 11. 1987-1991 lake-bottom change map comparing profile data from Warzyn Engineering, Inc. (Jun 1987) and ISGS (Aug 1991).

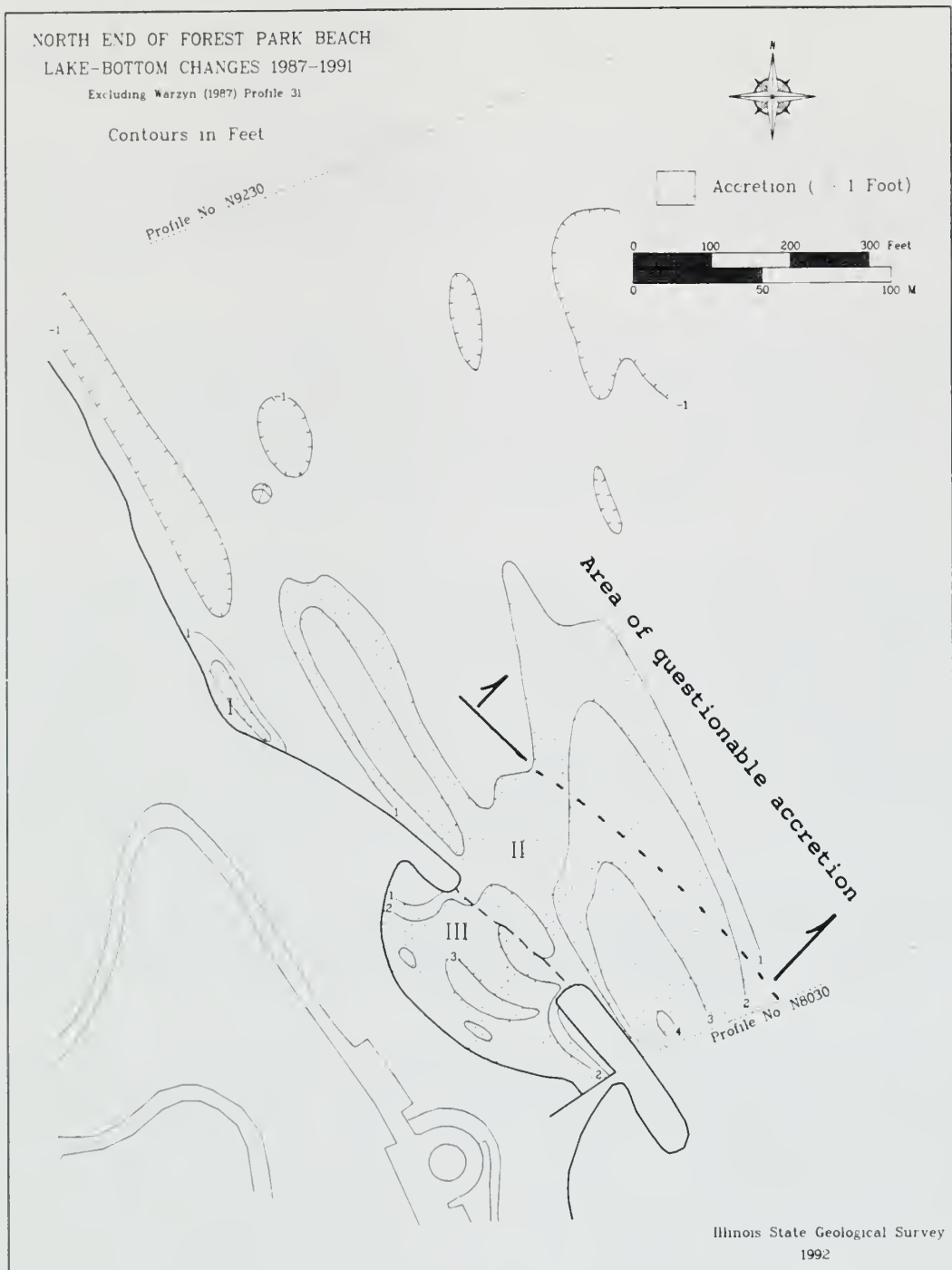


Figure 12. Alternate 1987-1991 lake-bottom change map comparing profile data from Warzyn Engineering, Inc. (WEI) (Jun 1987) and ISGS (Aug 1991) using bathymetry mapped without WEI profile 31.

are labeled (I) updrift accretion, (II) perimeter accretion, and (III) north-cell accretion.

The volumes of the accretionary areas were determined by calculating the areas between contours and multiplying these areas by the mid-contour values. For example, the area between a 1- and 2-foot contour was multiplied by 1.5 feet. The volumes within contours were summed for each of the three designated accretion areas.

The updrift accretion area (I) is a small area associated with the fillet developed updrift of the north breakwater. Since this mapping is based solely on bathymetric change, the accretion area represents lakeward translation of the shoreface. The volume estimate is a little more than 400 cubic yards. Total accretion in the updrift fillet is greater because this volume estimate does not account for sediment accumulated subaerially (*i.e.*, in the berm and backshore).

The perimeter accretion area (II) has a digitate component tangential to the northern breakwater, and a lobate area lakeward of the northern beach cell. In an ideal case for an accretion pattern showing bypass of these northern two breakwaters, the contours would be symmetric to the configuration of the breakwaters. The pattern shown for area II likely is somewhat influenced by irregularities in the 1987 depth/position data from WEI. The northeastern part of accretion area II is anomalous in that it suggests that an influx of sediment from the offshore area to the north. It is questionable if this is in fact an accretion area or an artifact of problems with the 1987 data.

The digitate part of area II tangential to the northern breakwater is the feature referred to in the report by the Lake Forest Shoreline Monitoring Committee (1990a) as the sand bar at the northern end of the project.

A clarification of terminology is necessary. This feature is not a "bar", in the common usage of the term, which is an offshore ridge with a crest significantly above the adjacent lake bottom. This accretionary area is a subtle feature. Examination of the profiles that cross this feature (profiles N9230; N8830; N8630; N8430) show a minor undulation on the bottom. The feature does not have enough relief to be distinguished on the 1-foot contour interval bathymetric map except in the northernmost part of the map area. (figs. 9 and 10). Since the term "bar" has connotations of relief greater than this feature, a more correct term for all this perimeter accretion is an accretionary lens or prism.

The maximum accretion in area II has occurred lakeward of the second breakwater from the north (Breakwater V). This is consistent with this breakwater having farther lakeward protrusion than the northern breakwater (Breakwater VI) and thus being adjacent to greater depths. A broad area adjacent to the second

breakwater has had three feet of accretion. One or two data points indicated a localized maximum of four feet (Fig. 12). This accretion is all necessary to build an accretionary prism to facilitate natural bypass of the project. The accretion pattern is consistent with an early to advanced stage of natural bypass.

The volume estimate for accretion in area II is just over 13,000 cubic yards. This volume estimate is likely somewhat too high because it includes the northeastern part of area II which is mapped with some uncertainty. If the volume for the northeastern part of area II (east of the dashed line shown on Figure 12) is discounted, then the volume estimate for area II is 9,500 cubic yards. Volume estimates for the accretionary prism (sand bar) have been 10,000 cubic yards (Lake Forest Shoreline Monitoring Committee, 1990a) and recently $7,000 \pm 1,800$ cubic yards (CH2M Hill, 1992).

There is overall agreement with these volume estimates. It is reasonable that there is some variance in the volumes because different methods have been used in the volume calculations and because the areal limits for the volume calculations have not been consistent. The implication from the overall agreement of the volume estimates by ISGS and CH2M HILL compared with the earlier estimate by the Lake Forest Shoreline Monitoring Committee (1990a) is that since this previous estimate there has not been any appreciable gain in volume for nearshore accretion on the updrift end of the project.

Previous volume estimates of approximately 30,000 cubic yards of updrift accretion can not be substantiated. There are numerous restraints that would preclude such an updrift accretion volume such as the design of the project's updrift end, the limited lakeward protrusion of the structures, the pre-construction nearshore bathymetry and the local littoral sediment supply.

The north cell accretion area (III) is all subaqueous accretion in the northern cell landward of the breakwater centerline. Up to 3.5 feet of sediment has accumulated in the central area of this cell based on the 1987 to 1991 comparison. Figure 13 compares profiles across this cell from 1987 (WEI) and 1991 (ISGS) showing the degree of accretion. The volume estimate for the north cell accretion is 3,500 cubic yards.

As discussed in a subsequent part of this report, during field work at Forest Park Beach in 1991, ISGS noted the accumulation of fine sand across the swash zone of the northern beach cell. Although there was speculation about entrapment in the northern cell, this data analysis by ISGS is the first documentation to verify such entrapment. The volume estimate of 3,500 cubic yards is a volume previously not accounted for in discussion of accretion in the updrift and northern part of Forest Park Beach. As documented in the grain-size analysis by CH2M

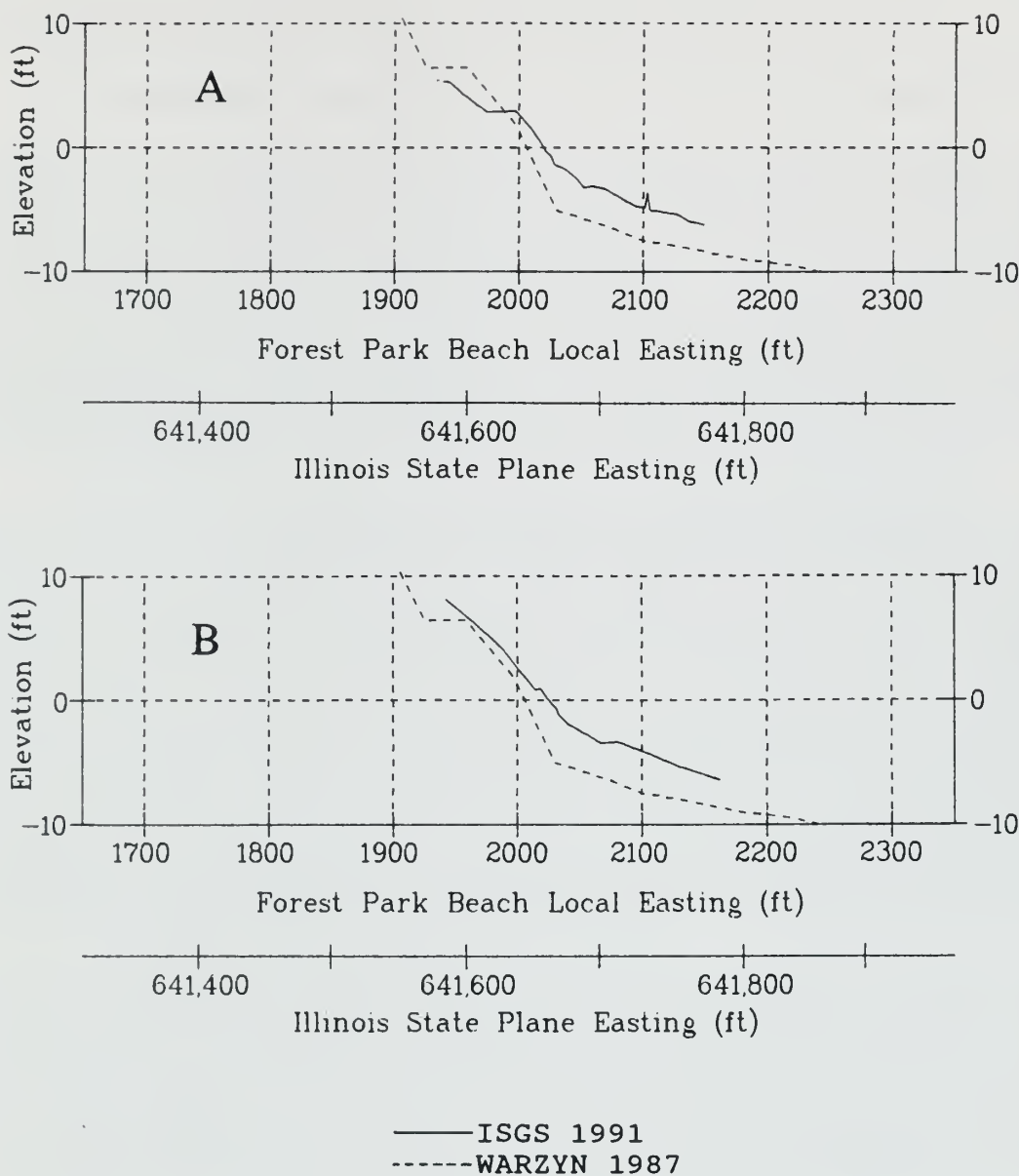


Figure 13. 1987-1991 profile comparison in the northern beach cell. A) comparison of Warzyn Engineering, Inc. (WEI) profile 27 and ISGS August profile N8300. B) comparison of WEI profile 27 and ISGS August profile N8200. WEI profile 27 is midway between the two ISGS profiles. ISGS profile N8300 (A) was projected south; ISGS profile N8200 (B) was projected north.

HILL (1991) for samples S2B and S2C from this northern cell, the sediment accumulation is fine sand on the Udden-Wentworth grain-size scale.

OBSERVATIONS RELATED TO 1991 DOWNDRIFT NOURISHMENT

In compliance with the recommendations of the previous monitoring report (Lake Forest Shoreline Monitoring Committee, 1990a), in 1991 the City of Lake Forest supplied sediment to the downdrift side of the Forest Park Beach to compensate for sediment trapped on the updrift side of the project. This nourishment occurred on August 22 and 23, 1991. This was the first year of a planned period of three consecutive years of nourishment that will add a total of 10,000 cubic yards to the littoral-drift system. In 1991, 3,000 cubic yards of sand was delivered by truck and discharged along the more lakeward half of the south-facing, rubble-mound revetment that forms the southern limit of the project.

ISGS monitored the nourishment operations on August 22. Figures 14, 15, 16, and 17 show different aspects of the nourishment operation on that day. After trucks dumped their load atop the revetment (figs. 14 and 16), front loaders pushed the sediment over the side (figs. 14, 15, 17) and built a peninsula into the nearshore zone. This peninsula (fig. 15) was oriented on an azimuth just lakeward of the end of the first groin south of the project. The orientation was intended to aid the southward sediment dispersal and to prevent having the nourishment trapped primarily in the northernmost groin compartment. This northernmost compartment is also the point of discharge for a stream, and disrupting or ponding this drainage was not desirable. At the end of truck delivery and distribution by front loader, all nourishment sediment was washed from the revetment by water directed by high-pressure hose.

On August 31, 1991, samples of the nourishment sediment were collected by the ISGS for grain-size analysis. Three samples were collected from the nourishment pile about 10 feet beyond the revetment. By this date wave-induced dispersion was nearly complete and only a remnant of the original nourishment stockpile had any subaerial expression. Four- to six-foot waves from the northeast on 30 and August 31, 1991 ultimately eliminated all subaerial expression of the stockpile. The nourishment sediment was distributed as a veneer across the beaches of the groin compartments south of the project at least as far south as the fourth compartment (i.e., the beach at Profile N4667).

Grain size analysis of the nourishment sediment was performed by the ISGS Quaternary Materials Laboratory. The sieve screens ranged from -2.50 to 5.00 phi in half-phi intervals. ISGS laboratory results are included in APPENDIX D (also fig. 18).



Figure 14. View of early stages of sand delivery and dispersion during beach nourishment. Photo date: August 22, 1991.



Figure 15. View of front loaders pushing nourishment sediment lakeward of the rubble-mound revetment. Note the nourishment stockpile is aligned lakeward of the groin field to the south. Photo date: August 22, 1991.



Figure 16. View of nourishment operations looking northward across first groin compartment south of Forest Park Beach. Photo date: August 22, 1991.



Figure 17. View of near maximum southerly extent of the nourishment stockpile. Photo date: August 22, 1991.

Based on the graphic statistics, median diameters of each of the three samples are 0.57 mm, 0.57 mm, and 0.77 mm (0.82, 0.80 and 0.51 phi respectively). The sediment classification according to the Udden-Wentworth grade scale (Wentworth, 1922) is a coarse sand. CH2M HILL collected and analyzed one sample from the nourishment sediment (Sample R-1) and obtained nearly equivalent grain-size distribution (fig. 18). A difference is that the CH2M HILL analysis resulted in a slightly finer median diameter. This difference may reflect the grain size variability in the nourishment sediment or may reflect a wave-induced reworking of the sand as the stockpile was being dispersed. Median diameter of the "Birds Eye" sand used in the beach construction is approximately 2.8 mm (Anglin et al., 1987).

The 1990 monitoring report recommended that "coarse sand" be placed on the south side of the project to mitigate erosion that might occur downdrift as a result of entrapment of sand in the updrift bar (Lake Forest Shoreline Monitoring Committee 1990a). The grade scale to be used in determining the grain size of the coarse sand was not specified. The sand added by the City of Lake Forest on August 22 and 23, 1991 was coarse sand on the Udden-Wentworth and USDA grade scales but medium sand on the Corps of Engineers and Bureau of Reclamation grade scales.

A critical question is how the 1991 nourishment sediment compares in grain size to the sediment accumulated in the updrift area of the project. Figure 19 shows the location of all 11 sediment samples in the northern part of the project that were collected and analyzed by CH2M HILL. Figure 20 compares the ISGS analyses of the nourishment sediment with the suite of 11 samples. The samples having median diameter coarser than the nourishment sediment are those collected at the waterline north of the north breakwater (S1W), at the waterline in the northern two beach cells (S2W; S3W), and in the backbeach and accretion area updrift of the north breakwater (S1B; S1A). The waterline samples represent the high-energy environment near the wave plunge point where finer-grained sediments are winnowed. Samples S1A and S1B represent the mixed sand and gravel of the upper foreshore and berm of the updrift fillet. Other than these five samples, all other samples collected and analyzed by CH2M HILL have median diameters finer than the nourishment sediment. Figure 21 specifically compares the 1991 nourishment sediment with sediment atop the offshore "bar" (S10), adjacent to the "bar" (S13) and samples from the cell breakwater centerlines in proximity to the pathway for littoral sediment that is passing the north end of the project (S2C, S3C). The nourishment sediment analyzed by ISGS has a median diameter essentially in the range of 0.6 to 0.8 mm. All samples from the bar area and bypass pathway are consistently less than 0.3 mm median diameter.

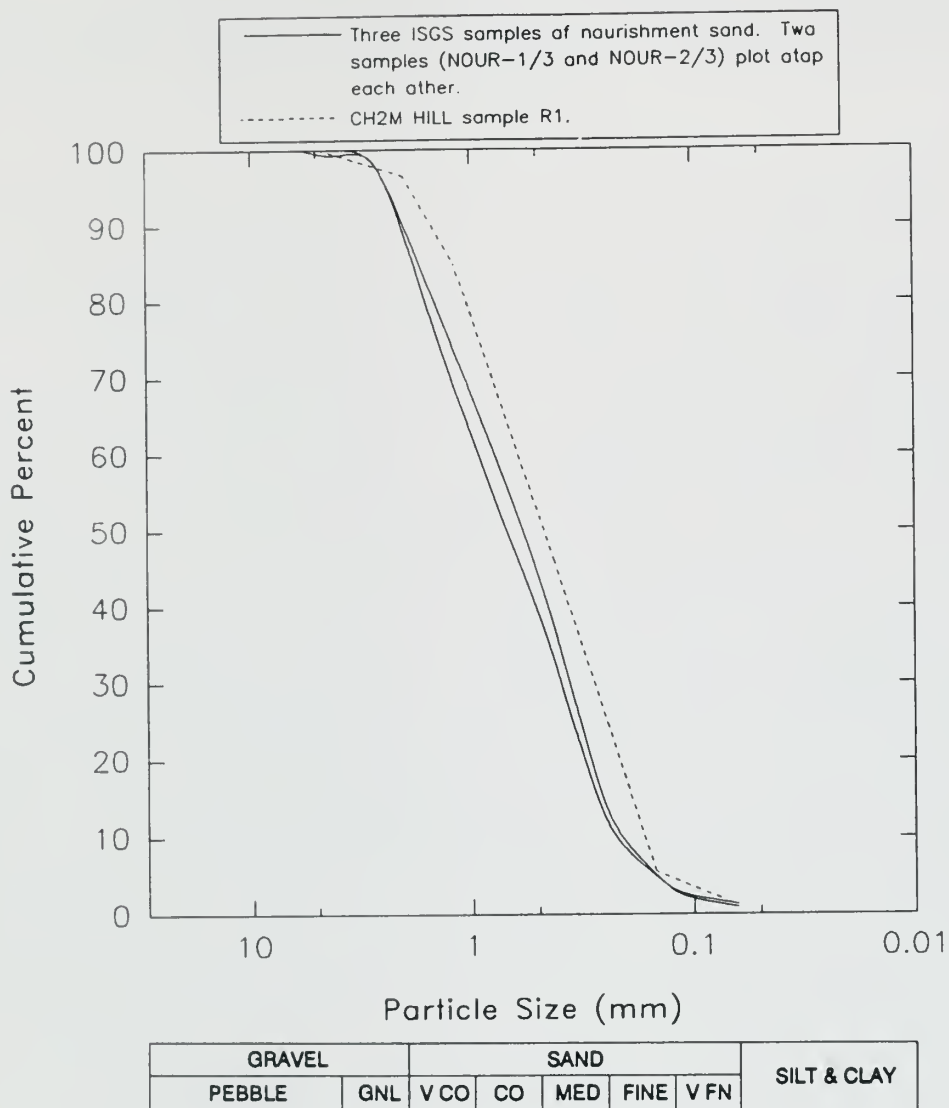


Figure 18. Grain size curves of nourishment sediment analyzed by ISGS compared to sample collected and analyzed by CH2M HILL.

This comparison of grain size has major significance with regard to the 1991 mitigation effort of beach nourishment. The median grain size of the 1991 beach nourishment: 1) exceeds the median grain size of sediment in the nearshore updrift of the project, that is, atop the so called bar; 2) exceeds the median grain size of the sediment atop the accretionary prism that is a bypass pathway around the north end of the project; and 3) exceeds the median grain size of the sediment accumulated in the northern two beach cells.

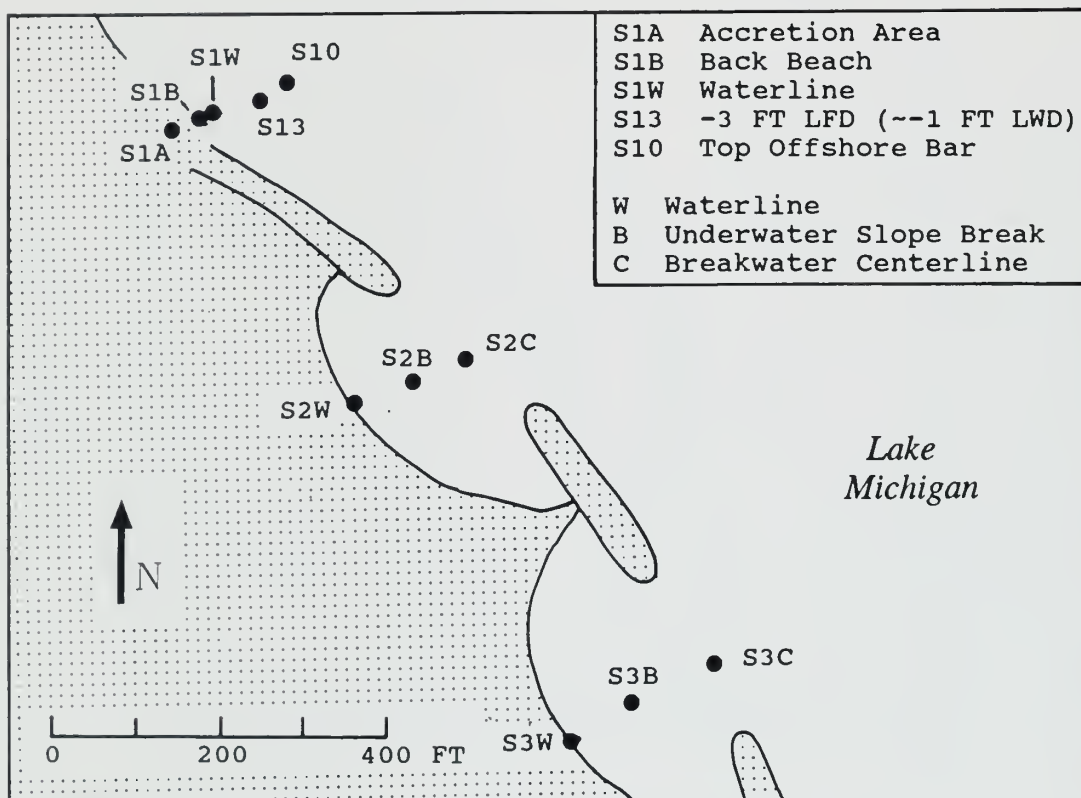


Figure 19. Location and designation of bottom sediment samples collected and analyzed by CH2M HILL.



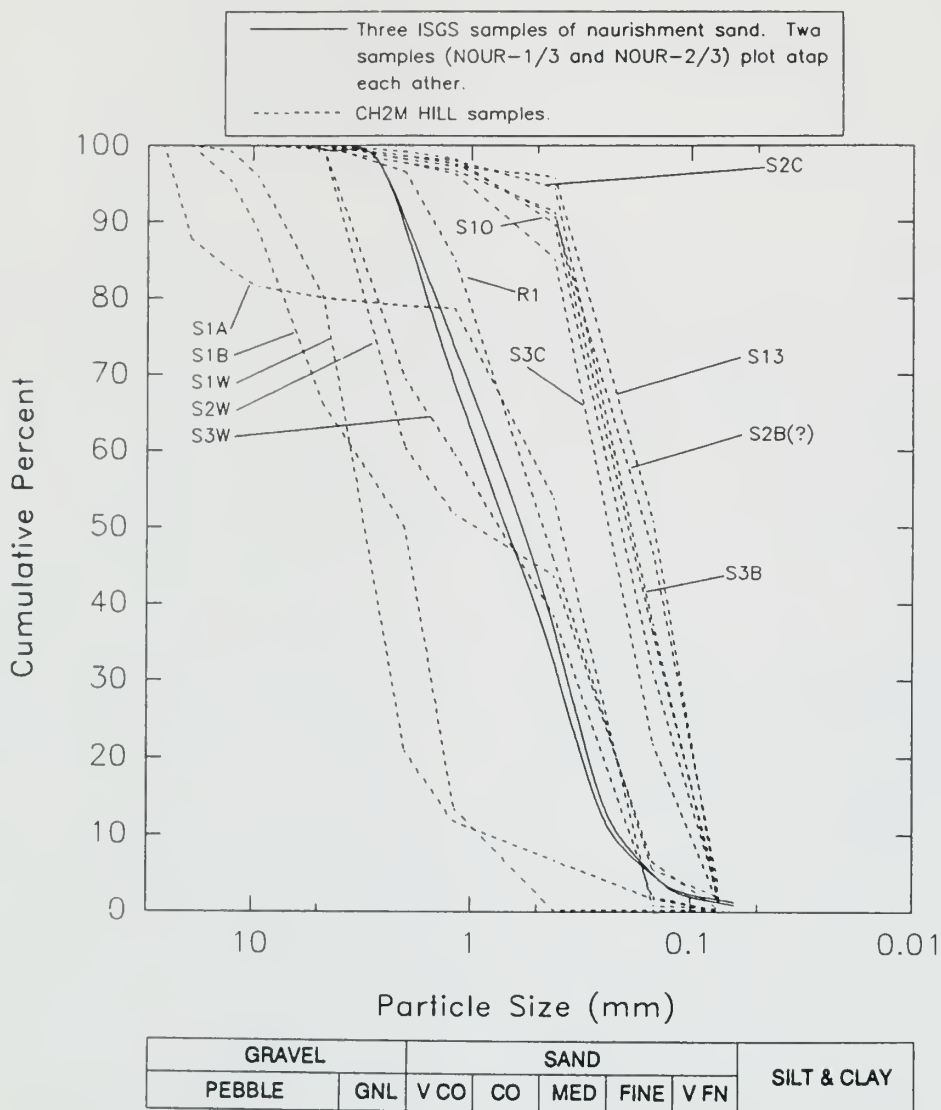


Figure 20. Grain size curves for the nourishment sediment analyzed by ISGS compared to curves for all sediment samples collected and analyzed by CH2M HILL.



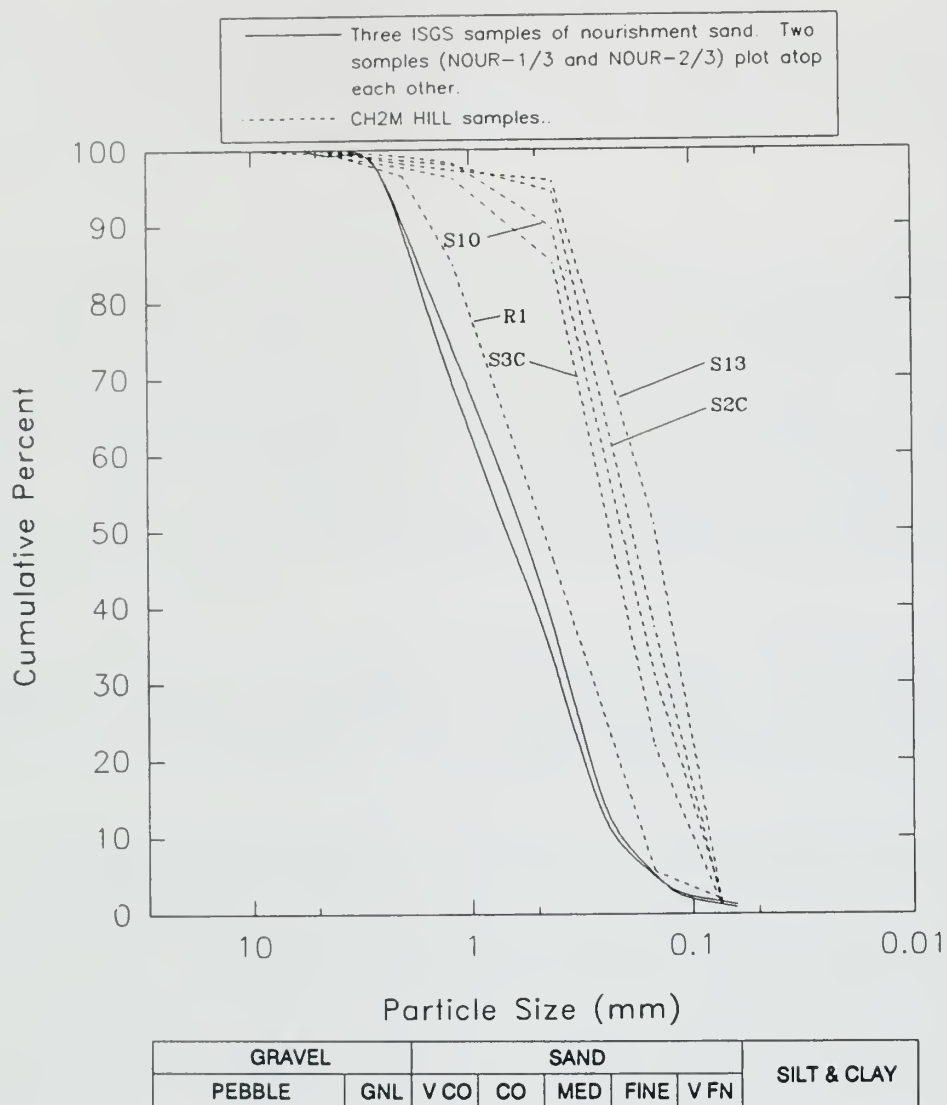


Figure 21. Grain size curves for the nourishment sediment analyzed by ISGS compared to samples analyzed by CH2M HILL from the upper shoreface north of the north breakwater (S13), atop the nearshore bar (S10), and samples on the centerline between the breakwaters of the northern two beach cells (S2C; S3C).

PART 2: COASTAL PROCESSES

INDICATIONS OF LITTORAL SEDIMENT BYPASS

The rate and efficiency at which littoral sediment may bypass the Forest Park Beach project is an important concern that will need to be thoroughly evaluated by the end of this five-year monitoring program. Based on 1991 field observations and data collection, and comparison with data from the earlier monitoring program, it is possible to make some generalizations concerning the present state of littoral sediment bypass.

Aerial photography of the Illinois shore of Lake Michigan was collected by IDOT in the spring of 1991. The lakeshore at Lake Forest was photographed on April 24, 1991 at about 1030 CST. This photography corresponded to a time of approximate 1-foot northeasterly waves, and closely followed a time of higher waves and substantial littoral sediment transport. An abundance of suspended sediment along the nearshore is a remnant of the preceding time of higher wave energy. Suspended sediment is not of major concern as useable sediment for beach stability, but the transport patterns of nearshore suspended sediment provide limited insight as to the transport pathway of coarser sediments moving at or near the lake bed.

Figure 22 shows a line drawing that traces the limits and major contrasts in suspended sediment concentration for April 24, 1991. This mapping is based solely on a visual comparison of the relative opaqueness of the water. The line drawing was made directly from the 1:3,600- scale IDOT color photography.

A narrow band of suspended sediment north of the project parallels the shore and arcs lakeward around and symmetric to the breakwaters. The width of the suspended sediment plume around the breakwaters ranges from a maximum of about 125 to a minimum of 50 feet with the minimum width occurring around the lakeward-most protrusion of the project. Sun glare masks the details of the suspended sediment plume opposite the southernmost breakwater and the boat-launch basin. However, a continuous plume apparently passes this area, generally parallel to the shore structures, and continues south to join the suspended sediment plume that parallels the shore south of Forest Park Beach. Measured from the lakeward ends of groins and shore structures, the width of the plume updrift and downdrift of the project is about 125 to 150 feet. Wider widths of the plume compared to that lakeward of the project is consistent with the shallower water depths.

For the wave and current conditions of this photo date, it is apparent that the Forest Park Beach project does not contribute to any removal of suspended sediment from the littoral sediment stream by offshore deflection. A band of

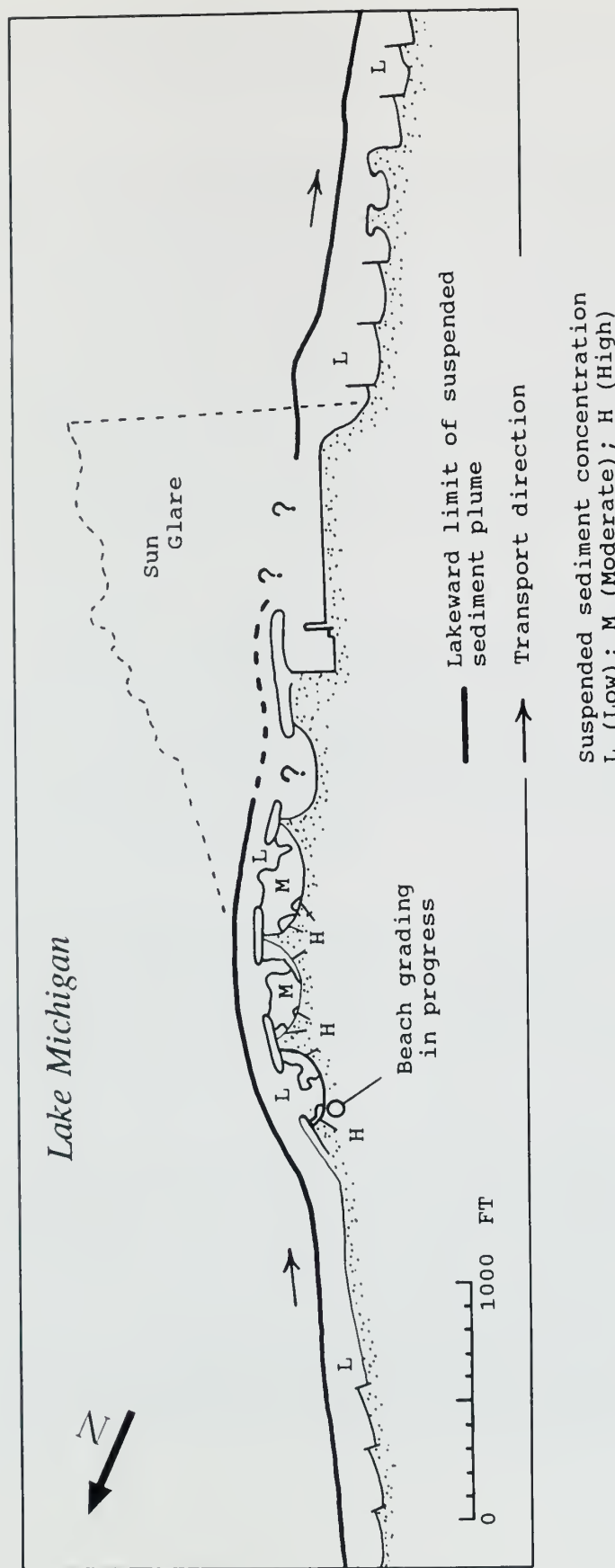


Figure 22. Line drawing showing limits of the suspended sediment plume in the Forest Park Beach vicinity on 24 April 1991. Drawing is traced from IDOT aerial color photographs (R3510C/ST-2 Nos. 690 and 688; 1:3600 scale). Concentration designations are relative comparisons based on opaqueness of the water.

nearshore suspended sediment having rather uniform width is continuous updrift, lakeward and downdrift of Forest Park Beach.

Evidence for sediment bypass along the lake bed occurs in a comparison of the location of the sand/glacial-till interface documented for several years in the previous monitoring report (Lake Forest Shoreline Monitoring Committee, 1990a, 1990b) and documented in the 1992 report by CH2M HILL. Previous mapping of the interface was based on fathometer trace showing the smooth surface of the nearshore sand apron and the irregular surface across the glacial till. Along the Lake Michigan coast, previous work has demonstrated that this contact can be identified with reasonable certainty on fathometer traces if the fathometer data are collected during calm water. For example, the ISGS data collected in October on profile N8430 shows this contact at the 360-foot (110-meter) mark (see APPENDIX A). The 1991 mapping by CH2M HILL is different than the three previous mappings in that the contact was identified by diver inspection according to procedures described in the CH2M HILL report.

Figure 23 compares the location of the sand/glacial-till interface for 1986, 1988, 1989 and 1991. Along the lakeward side of the project, the 1986 and 1988 contacts generally parallel the pre-construction shoreline and have the interface at about the position of the breakwaters. North of the project, location of the interface has not changed significantly between 1986 and 1991. The major difference is that off the northernmost breakwater, the 1991 interface diverges from the earlier interfaces and continues south lakeward of the breakwaters within a band no more than 300-feet wide.

Previous discussion of the accretion lakeward of the northern two breakwaters provided the evidence that bypass has extended at least as far south as the second breakwater from the north (Breakwater V). The inference from this comparison of the location of the sand/glacial-till interface over five years of monitoring is that littoral sediment is bypassing the project at least as far south as the southern beach cell.

An anomalous feature depicted by 1991 CH2M HILL mapping compared to the previous years is the landward deflection of the sand/glacial-till interface south of Forest Park Beach. The implication from this mapping is that the nearshore, south of profile N5067, has been stripped of the sand apron that was present in 1986 and 1988. One of the monitoring concerns at Forest Park Beach is any adverse sedimentary impact downdrift of the project. **Before a conclusion can be drawn that an adverse impact has occurred in the downdrift area, it is imperative to note that the difference in location of the interface may in fact relate to differences in mapping procedures and not indicate any actual lake-bottom change.**

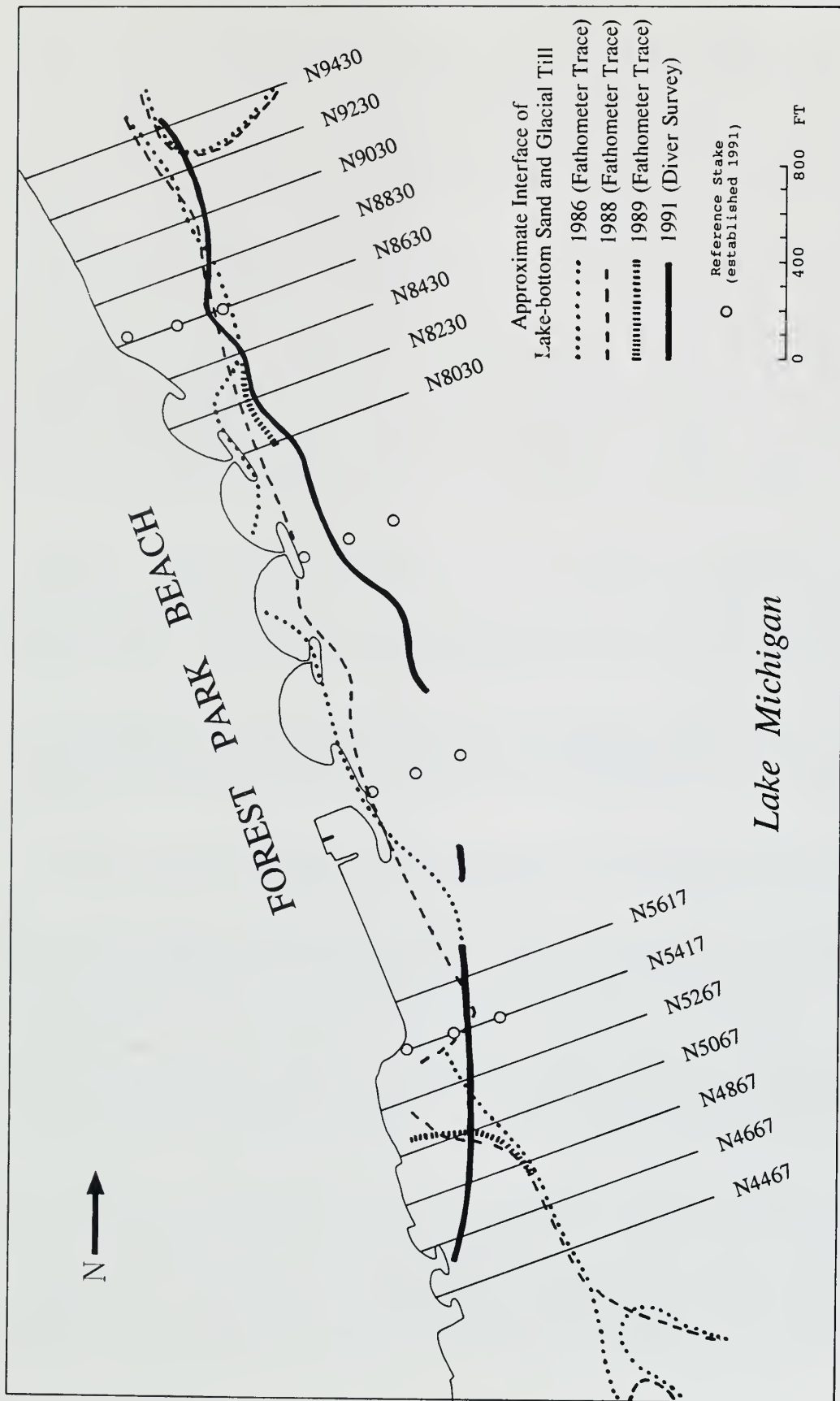


Figure 23. Location of the interface of lake-bottom sand and glacial till. 1986, 1988 and 1989 mapping from Lake Forest Shoreline Monitoring Committee (1990b); 1991 mapping from CH2M HILL (1992).

The profile collected by ISGS on line N4667 during calm water conditions of 9 October shows a change in lake-bottom morphology at the 656-foot (200 meter) mark between a smooth (sand?) and irregular (glacial-till?) bottom at about 475 feet (145 meters) lakeward of the rubble-mound breakwater (see profile N4667, APPENDIX A). This interface location identified on the ISGS fathometer trace is in near perfect agreement with the interface location mapped in 1986 and 1988. It could be argued that this October 1991 fathometer trace shows a rejuvenated sand cover resulting from dispersion of the August 1991 beach nourishment. However, this interface is 475 feet lakeward of the breakwater which is significantly farther lakeward than this coarse sand would be dispersed. The acoustic reflection characteristics of the local lake-bottom sediments may be a factor for an anomalous result compared to the diver survey. Alternatively, the mapping method in the diver survey may not be appropriate if the sand cover in this area has a thin and patchy nature. The method used by CH2M HILL involved mapping location of the sand cover at the point lakeward of which sand may still be present; however, sand thickness over this area is six inches or less.

The lack of previous diver survey precludes comparison of similar mapping methods. Future diver surveys in this area need to continue to use the procedures established by CH2M HILL in 1991, and the diver surveys should extend lakeward to evaluate bottom sediment characteristics between where the interface was mapped in 1991 and where it had been mapped in 1986 and 1988.

It is important to reemphasize that the discrepancy regarding location of the sand/glacial-till interface south of Forest Park Beach warrants further evaluation before any assessment can be made regarding changes in the location of this interface.

INDICATIONS OF BEACH CELL SUBAERIAL SEDIMENT ENTRAPMENT

The IDOT photo documentation used in generating Figure 22 records an opaqueness in the northern three beach cells that exceeds the opaqueness of the suspended sediment on the north, south and lakeward sides of the project. The southern beach cell can not be evaluated because of sun glare. Using the opaqueness of the updrift, downdrift and bypass plume for comparison, the suspended sediment within the beach cells can be mapped into relative high and low concentration areas as shown on Figure 22. The increased turbidity within the cells suggests a concentration and possible entrapment of fine-grained sediment.

A possible contributing factor to the cell turbidity is beach grading operations which were occurring at the time of this photo. A large machine grading the beach is visible near the northernmost cell. However, entrapment of fine-grained sediment was observed by the ISGS in the northern two cells during ISGS site visits on two occasions (July 03 and October 09 1991). These visits closely followed several days of high waves and nearshore entrainment of suspended

sediment. On both occasions a thin veneer of fine sand blanketed the foreshore of the northern two cells to the maximum reach of the high-wave swash zone. These veneers of fine sand are not persistent features, because they are mixed with the coarser "Birds Eye" sand of the project during beach maintenance grading.

LITTORAL SEDIMENT TRANSPORT PROCESSES IN RELATION TO FOREST PARK BEACH

Introduction

Littoral sediment transport in the vicinity of Forest Park Beach has been central to the concerns about the possible impact of this project on local and regional coastal processes. These concerns are complicated by the lack of data specifically addressing littoral sediment supply and transport rates in the vicinity of Forest Park Beach. No littoral transport data were collected by the ISGS during 1991 at Forest Park Beach. However, a general perspective on transport processes can be gained from an evaluation of the local and regional coastal geology, historical changes to littoral transport along the Illinois coast, and the characteristics of Forest Park Beach compared to other coastal developments on the Illinois lakeshore. The purpose of the following discussion is to give a proper perspective as to how the Forest Park Beach project relates to historical and present-day human influence on Illinois lakeshore littoral processes.

Predevelopment Setting

In the predevelopment setting, the coast at Lake Forest was within the pathway for net southerly littoral transport along the western shore of southern Lake Michigan. This net southerly transport originated on the Wisconsin coast at least as far north as Sheboygan and possibly as far north as Manitowoc (Hands, 1970; Chrzastowski, 1991). From here southward, waves from the north and northeast, which is the direction of greatest fetch, had net influence on wave-induced transport of sediment. Although southerly waves would produce intermittent northerly transport, the net transport was to the south. No coastal promontories or embayments interrupted the net southerly littoral transport, and a continuous littoral stream existed to the southern margin of the lake along the Indiana shore. Here, between Gary on the west and Michigan City on the east, was a convergence zone of littoral sediment from the western and eastern shores of southern Lake Michigan (Chrzastowski, 1990a; Chrzastowski and Thompson, in press).

Sediment supply to the littoral stream was from erosion of morainal bluffs along the lake margin, erosion of beaches, and to some degree, possibly erosion of the lake bottom across the nearshore zone. Rivers did not provide any significant sediment supply. All morainal bluffs and beaches along the Illinois coast, including the bluffs and beaches at Lake Forest, were erosional and contributed to the sediment supply. The erosional character of these bluffs is documented in historical photographs showing the lack of vegetation along the bluffs which is a testament to the slope instability. Recession of these bluffs was the result of both

coastal erosion along the bluff toe and natural mass wasting of the bluff slopes independent of wave action.

In the predevelopment setting, all of the Illinois coast was erosional except for the shore between southern Zion and North Chicago. This reach is the southern (downdrift) end of the Zion beach-ridge plain consisting of low-lying sand ridges and wetlands extending along the coast from Kenosha, Wisconsin to North Chicago. Much of the Illinois part of this plain is preserved in Illinois Beach State Park. This plain is a gravelly sand body that has been migrating southward along the southern Wisconsin and northern Illinois coast by erosion along the updrift end and accretion along the downdrift end, essentially in a "tank tread" fashion. The leading edge of the plain moved south across the Illinois-Wisconsin state line about 3700 years ago (Larsen, 1985). By historical time, the southern limit of the plain was along what is now the lakeshore at North Chicago. In the predevelopment setting, the lakeshore at Lake Forest and neighboring communities would have received an influx of any littoral sediment that would pass the prime depositional zone along the southern end of the beach-ridge plain and continue southward. This influx would have been important to the stability and maintenance of the beach and nearshore sand body at Lake Forest and all along the Illinois bluff coast.

The annual volume of littoral transport along the Illinois coast in the natural setting would not have been uniform because transport volumes were influenced by variation in wave approach angle due to shoreline orientation, variation in nearshore bathymetry, and contrasts in the volume of sediment that may be gained or lost along different reaches. Rates of transport would also vary with changes in lake level. Based on accretion against the first major structures built along the Chicago lakeshore, an estimate of the natural transport rate along the Chicago lakeshore is about 100,000 cubic yards/year (Chrzastowski, 1990a). Based on historical profile comparisons along Illinois Beach State Park, estimate of transport rate along this beach-ridge plain is 90,000 cubic yards/year (U.S. Army Corps Engineers, 1953). Because this state park shore has remained in a near-natural setting, this estimate is a reasonable estimate of the natural conditions and is in agreement with the Chicago lakeshore estimate.

The natural-state littoral transport along the Lake Forest coast, as well as most of the Illinois bluff coast, was likely somewhat less than either of these two estimates because this shore did not have the abundant sediment supply of either the beach-ridge plain or the sand-dominated coast at Chicago. Through historical time there has been a continuing decline in littoral sediment supply and transport along the Illinois bluff coast due to structures curtailing coastal erosion and thus starving this shore of this sediment supply, as well as trapping much of the sediment available for transport.

Historical Barriers to Littoral Transport

The first structures to interrupt the natural transport of littoral sediments along the Illinois shore were jetties built by the U. S. War Department to straighten and defend the mouth of the Chicago River. Construction began on the south jetty in 1833, and on the north jetty in 1834 (U. S. Army Corps of Engineers, 1839). In historical accounts these structures are referred to as North Pier and South Pier, or simply the "government piers" (Andreas, 1884). The north (updrift) jetty required several extensions in length and orientation in attempts to prevent bars from building across the river mouth. Blockage of the littoral sediment stream resulted in a large beach accretion area against the north jetty (fig. 24). Today this is part of the "Streeterville" neighborhood of Chicago's near-north side.

Starvation of littoral sediment south of the Chicago River caused serious shore erosion and threatened South Michigan Avenue along the reach where this street now borders Grant Park. By the late 1840s, the threat to South Michigan Avenue had advanced to such a degree that in 1852 the City of Chicago allowed the Illinois Central (IC) Railroad to build trestles and a breakwater to extend tracks from the then southern city limits about 1.4 miles south of the Chicago River to near the south bank of the river. The track extension provided an effective shore defense for South Michigan Avenue, but erosion processes were then translated farther southward.

Construction of the Chicago River jetties marked the beginning of the end of littoral sediment supply from the Illinois lakeshore to the zone of littoral-drift convergence along the Indiana shore. Considering approximately 160 years of coastal development history (1834-1992), decreased littoral sediment supply and transport barriers along the Illinois shore has deprived the Indiana shore of approximately 16 million cubic yards of sediment ($160 \text{ yrs} \times 100,000 \text{ cu yds/yr}$).

Coastal development of the Chicago lakefront has resulted in an almost entirely engineered shore and a total of 5.5 square miles of lakefill (Chrzastowski, 1991). The "Burnham Plan" for lakeshore development proposed even more extensive shoreline modifications, lakefills and offshore islands (fig. 25). A prominent and significant lakefill protrusion is the Montrose peninsula which extends nearly one mile lakeward of the natural shoreline. This peninsula is significant because it is the first major barrier for littoral transport that reaches the Chicago lakeshore from the north, and although some littoral sediment may bypass this barrier, it essentially starves littoral sediment supply to the remaining Chicago lakeshore to the south.

The two shore features having the greatest potential for littoral sediment entrapment on the Illinois lakeshore are the lakefills for the Chicago Harbor complex (Navy Pier and the Central-District Water Filtration Plant), and on

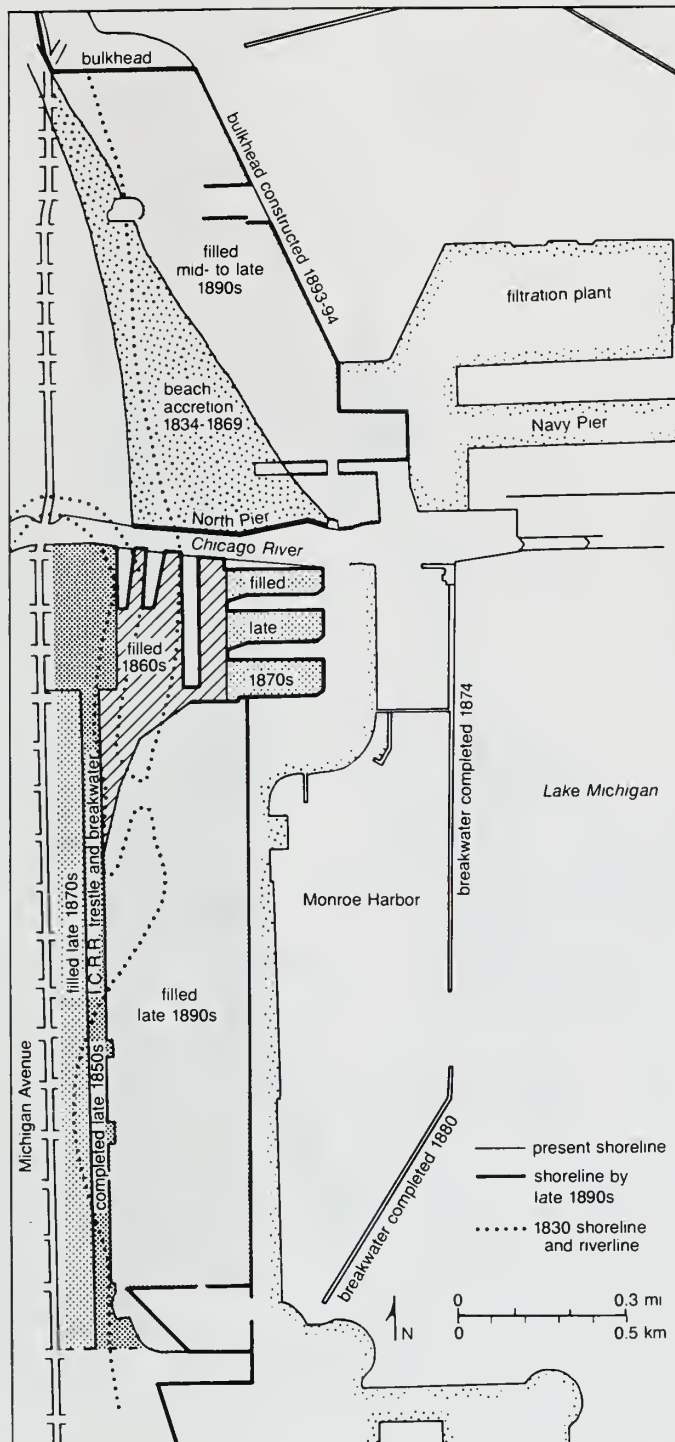


Figure 24. Shoreline changes along Chicago's central lakeshore during the mid- to late-1800s (from Chrzastowski, 1991).

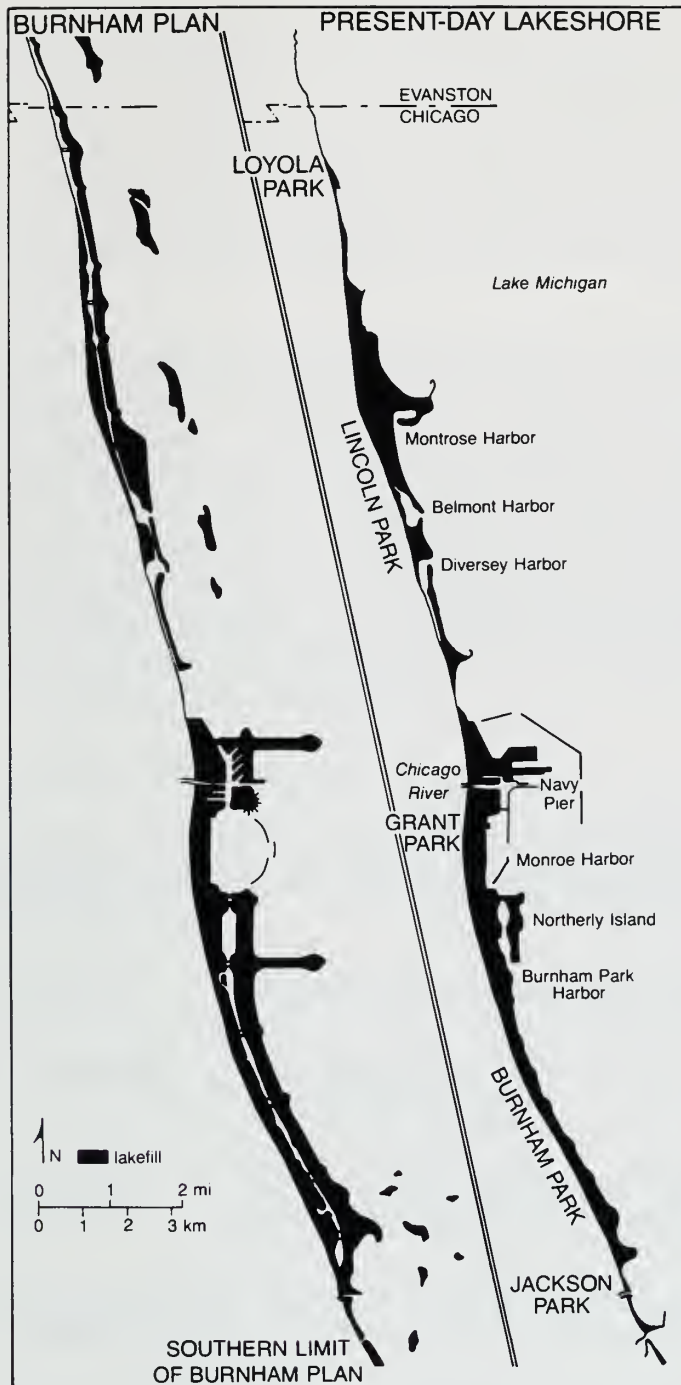


Figure 25. Extent of lakefills and shoreline modification along the present-day Chicago lakeshore, and comparison with the "Burnham Plan" for lakefront development (from Chrzastowski, 1991).

Chicago's far south lakeshore, the shore-attached breakwaters at Calumet Harbor (fig. 26). The potential for littoral sediment entrapment against these two barriers has never been realized, in large part because of their location along the sediment-starved coast downdrift of the Montrose peninsula. The man-made shore feature having greatest potential for littoral sediment entrapment along the entire Lake Michigan coast is the Indiana Harbor peninsula (fig. 26). However, this peninsula has essentially no impact on littoral sediment processes because it is within a sediment starved reach.

Human impact on the Chicago lakeshore has been extreme, but in terms of human interference creating barriers to littoral transport, no occurrence in Chicago or elsewhere on the Illinois coast compares to the impact from construction of the jetty and groin complex to defend the entrance to Waukegan Harbor. Because of a combination of the location at the downdrift end of this southward migrating beach-ridge plain, the abundance of littoral sediment supply, and the offshore extent of these structures, entrapment of littoral sediments has formed the largest areal and volumetric accretion on the Lake Michigan shore and one of the largest in the Great Lakes region (fig. 27). These structures have halted the process of southward migration of the beach-ridge plain.

Littoral Cells: Definition and Mapping

In previous work along the Indiana coast, Wood et al. (1988) defined shore structures according to the degree to which they interrupted the littoral sediment stream. These divisions are:

1. Primary structures: Total or near-total barriers to littoral transport
2. Secondary structures: Interceptors of littoral transport that allow substantial bypass
3. Tertiary structures: Minor interruptions of the littoral stream that allow near-total bypass (e.g., short-length groins)

The designation of a structure as primary, secondary or tertiary can change with time as accretion against a structure reaches capacity and greater bypass occurs.

This designation of structure type can also be applied to the designation of littoral cells that are bound by these structures. The transport of littoral sediment along the coast occurs within compartments or cells that are bound by natural promontories or man-made structures. Primary littoral cells are those bound by primary structures and have no littoral sediment crossing their boundaries. Within primary cells may be secondary cells bound by structures that allow bypass. Tertiary cells could be defined for the reaches between the minor barriers, but

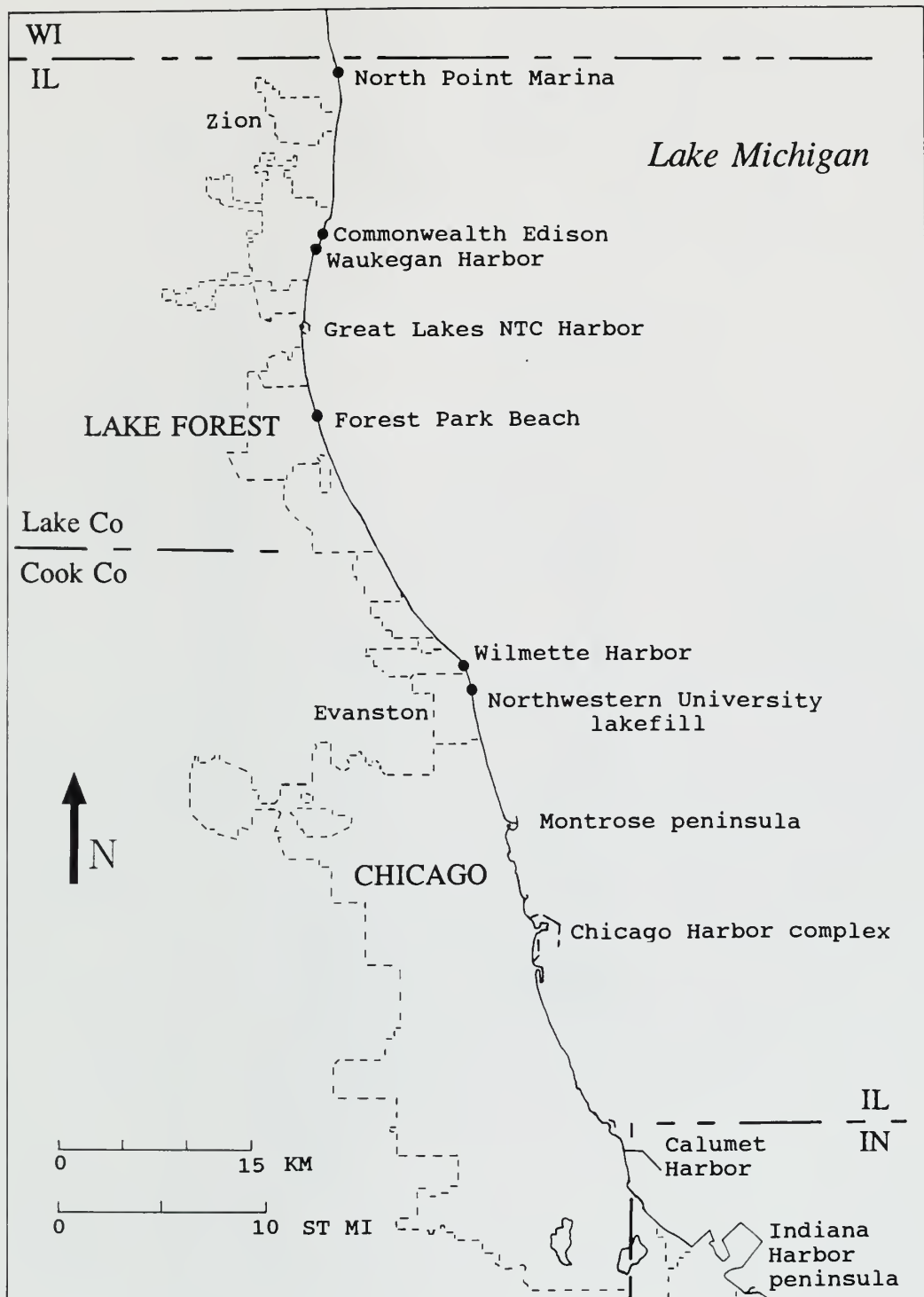


Figure 26. Location of Forest Park Beach in relation to major barriers to littoral transport along the Illinois shore.

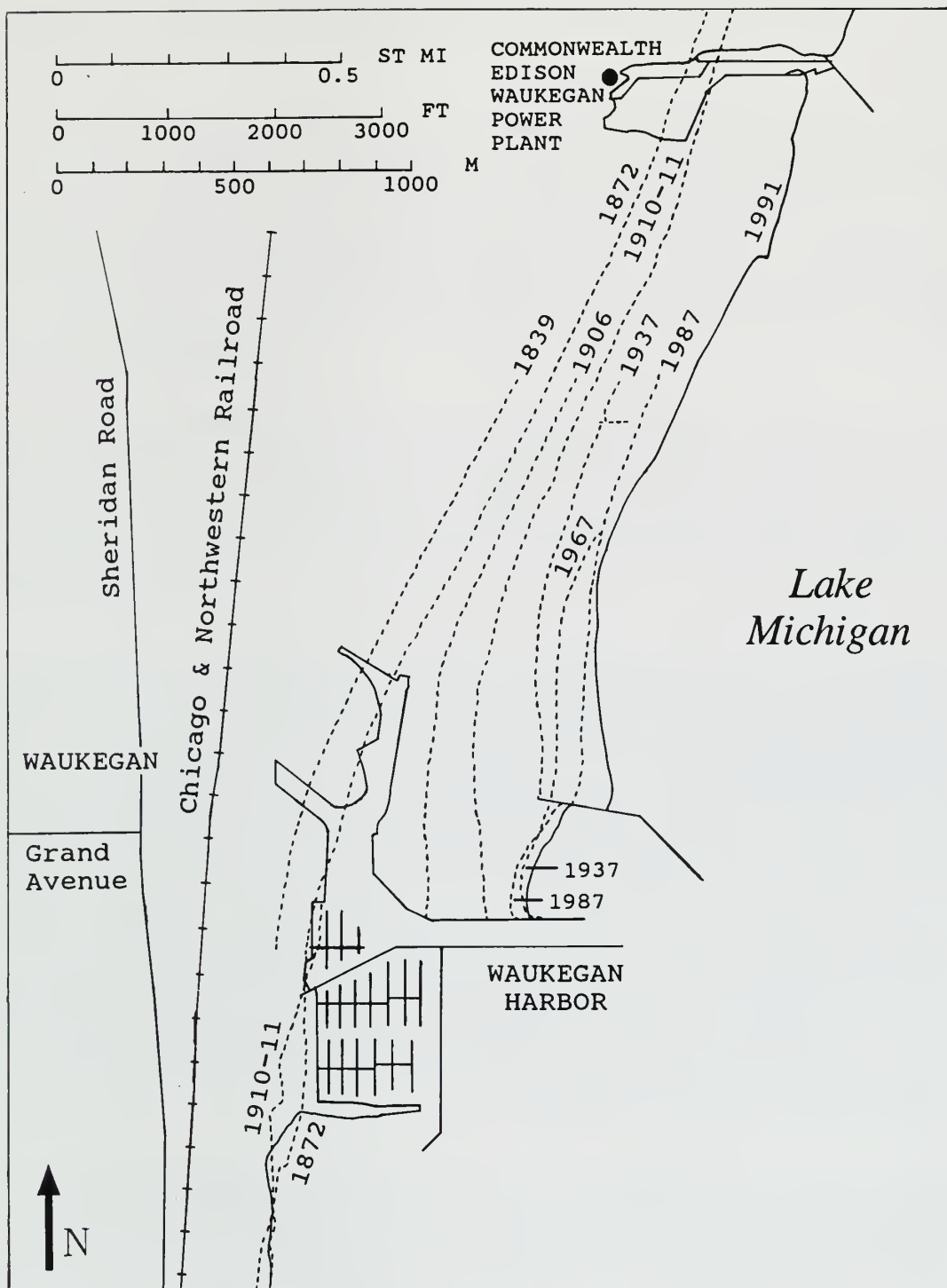


Figure 27. Historical shoreline changes in vicinity of Waukegan Harbor.

if considering regional transport patterns, such localized cells are of no major consequence.

For the Lake Michigan shore, a structure needs to extend into at least 18 feet water depth to function as a primary cell boundary. This is essentially the limit of littoral sediment transport and is thus the depth of closure (Wood et al., 1988; Hallermeier, 1983). A circumstance could arise with a structure extending into sufficient water depths to potentially be a total barrier to transport, but if dredging and artificial bypass maintain continuity of the littoral stream, this structure would be designated as a secondary cell boundary. The primary cell boundary would then be farther downdrift.

Figure 26 shows the location of Forest Park Beach in relation to the major (primary and secondary) barriers to littoral transport along the Illinois coast. The most recent barrier to be added to the coast is North Point Marina near the Illinois/Wisconsin state line. The lakeward protruding north breakwater of this marina, and the marina entrance, form traps for littoral sediment moving south across the state line.

The bathymetry bordering these barriers, the characteristics of lake-bottom sediments in the vicinity of these barriers, and local coastal management practices are the basis for delineating the primary and secondary cell boundaries shown in Figure 28. Two primary cells occur between the Illinois-Wisconsin state line and the northern Chicago lakeshore. The breakwaters and basin at Great Lakes Naval Training Center (NTC) are designated as the northernmost primary cell boundary. The reason for the primary cell division at Great Lakes NTC rather than at Waukegan Harbor relates to ongoing coastal management of artificially bypassing sediment dredged. The second primary cell boundary progressing south (downdrift) along the coast is the Montrose peninsula. Three additional primary cells and several secondary cells occur between Montrose peninsula and the Illinois-Indiana state line, but are not shown on Figure 28. The cells are given an alpha-numeric designation to correspond to an ongoing mapping project distinguishing littoral cells along the Illinois and Indiana coast (Chrastowski et al., in prep).

Littoral sediment supply to primary cell IL-1 originates along the southern Wisconsin coast and is limited to what can naturally or artificially bypass a marina-entrance channel on the Wisconsin side of the state line (Prairie Cove Marina). North Point Marina, the jetty-defended cooling-water basin at the Commonwealth Edison Waukegan Power Plant, and the jetty-defended Waukegan Harbor form secondary cell boundaries. Although the jetties at Waukegan Harbor were a primary barrier in the past, dredging of the entrance and downdrift disposal to the nearshore results in artificial bypass. The southern limit of primary cell IL-1 is the shore-attached breakwater and basin at Great Lakes Naval Training Center (NTC).

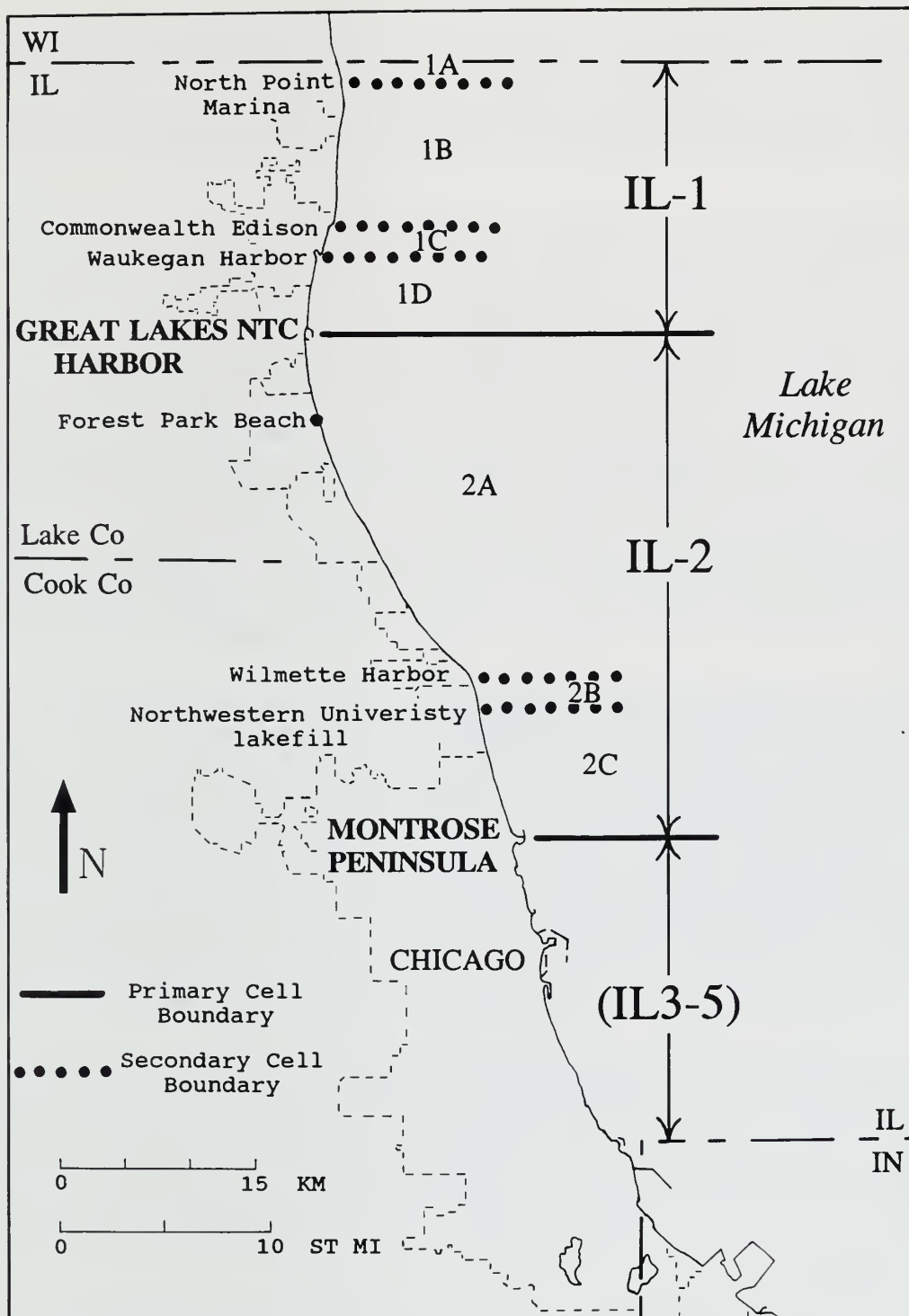


Figure 28. Division of the Illinois coast into primary and secondary littoral cells. Cell boundaries are not shown for the primary and secondary cells between Montrose peninsula and the Illinois-Indiana State line.

Here a large accretion area occurs on the updrift side of the breakwaters and within the harbor. At present, based on available data, there is no appreciable littoral sediment bypass of this harbor. However, it is important to note that data on sediment transport in the harbor vicinity are limited, and natural bypass may be occurring.

Forest Park Beach is in the northern reach of primary cell IL-2 which extends from Great Lakes NTC southward to Montrose peninsula. Wilmette Harbor and the Northwestern University lakefill are additional secondary cell boundaries in this primary cell. Northwestern University lakefill is an example of a primary cell boundary for several years following construction. Eventually the updrift accretion reached capacity and bypass began. Recent surveys along the lakeward perimeter of the lakefill have documented an accretionary wedge which is the result of and facilitates littoral-sediment bypass. The terminus of the primary cell is a broad accretion area across the nearshore north of Montrose peninsula. A northward projecting groin on the lakeward end of the peninsula aids the entrainment capabilities. Jet probings in this area indicate that the accretion of lake-bottom sand updrift of Montrose peninsula locally has thicknesses up to 15 feet (Pranschke and Brown, 1988).

Forest Park Beach is only 3.5 miles south of Great Lakes NTC Harbor, and thus as long as this harbor is a total or near-total barrier to littoral transport, the interaction of Forest Park Beach with the littoral sediment supply is restricted to the supply and transport along this 3.5 mile reach. Defense of the bluffs along a majority of this reach has nearly eliminated all littoral sediment influx from bluff erosion. The supply of littoral sediment updrift of Forest Park Beach is thus limited essentially to erosion of beaches and the nearshore lake bottom. Forest Park Beach is therefore within a reach of "lean" littoral sediment supply. If this project were a total barrier, it would deprive the downdrift shore of littoral sediments limited to that available within this 3.5-mile reach.

Considering the littoral barriers along the northern Illinois lakeshore, a perspective is gained as to the significance of the Forest Park Beach project by comparing the offshore extent of the barriers referenced to the pre-construction shoreline, and the maximum lake depths to which the structures extend. Offshore extent is important to determine the area of potential updrift accretion, and perimeter maximum depth is important in order to accommodate natural bypass.

Table 3 compares lakeward protrusion and perimeter depth for Forest Park Beach and the seven littoral-transport barriers between the Illinois-Wisconsin state line and Montrose peninsula. Maximum depth along the lakeward margin of Forest Park Beach is comparable to that of the other barriers that allow natural bypass. In terms of lakeward extent, Forest Park Beach is an order of magnitude less than all barriers other than the jetty at the Commonwealth Edison cooling-water basin.

Table 3. Maximum lakeward protrusion and perimeter depth for the major littoral barriers on the northern Illinois lakeshore.

	Maximum Lakeward Protrusion ⁽¹⁾ <u>(feet)</u>	Maximum Perimeter Depth ⁽²⁾ <u>(feet LWD)</u>
North Point Marina Breakwaters	1070	12
Commonwealth Edison Jetty	670	5
Waukegan Harbor South Jetty	2850	22
Great Lakes NTC Harbor Breakwaters	2300	12
Forest Park Beach Breakwaters	410	11
Wilmette Harbor Jetties	1320	10
Northwestern University lakefill	1320	12
Montrose peninsula	4750	19-20

⁽¹⁾ Measured from pre-construction shoreline (nearest 10 feet).

⁽²⁾ Depth from NOAA charts, USGS quadrangles and/or ISGS bathymetric mapping (nearest 1 foot).

The maximum lakeward protrusion of Forest Park Beach is about 250 feet less than this jetty.

Although the Forest Park Beach project may have formed a near-total barrier to littoral transport during its early post-construction phase, the short lakeward protrusion and the arcuate form of the project's updrift end form a limited updrift accretion area. Lake-bottom morphology and sediment distribution indicate natural bypass is occurring. Additional updrift entrapment is likely precluded by geometric constraints. The potential for future entrapment is in the beach cells and the boat-launch basin.

PART 3: SUMMARY

RECOMMENDATIONS FOR FUTURE MONITORING AND REPORTING

To assure that the Forest Park Beach monitoring program is developing the best-suited database for evaluating coastal processes and geomorphic change, the monitoring program needs to be flexible to adjust to new findings or changes in the coastal-sedimentary dynamics. Page 11 of the CH2M HILL report includes five recommendations for improving the data collection in future surveys. Following are each of these five CH2M HILL recommendations with accompanying comments by ISGS.

CH2M HILL Recommendation 1:

The baseline surveys extended well beyond the sand-clay interface. Future surveys need not extend the full 2000 feet offshore, but rather need only extend far enough to incorporate this interface.

Comment: Agreed. The lakeward extent of the fathometer profiles run in 1991 is much longer than necessary. The zone of potential lake-bottom change is a rather narrow band along the shore, and these fathometer profiles extend lakeward across an expanse of glacial till. Accretion and erosion changes across this surface are best documented with measurements to reference stakes rather than comparison of fathometer profiles. All previous and new fathometer data indicate that profile closure can be achieved by extending offshore no more than 600 feet lakeward of the pre-construction shoreline to a water depth of, at most, about 14 feet LFD (as opposed to 18 to 20 feet water depth which is the accepted southern Lake Michigan depth of closure).

CH2M HILL Recommendation 2:

Additional survey lines should be added to the north end of the project. The present northern limit does not extend far enough to ensure that the sand bar is totally included in the survey.

Comment: Additional data northward of the present survey would be beneficial, but the mapping needs to focus more on the areal extent and geomorphology of this accretionary prism in its southern extent. Bathymetric data around the entire lakeward perimeter of the project (i.e., between long profiles N8030 and N5617) is of much greater need than extending the surveys northward. These data are needed to accurately map and evaluate the development and modification of the accretionary prism that forms the littoral sediment bypass of the

project. The ISGS lake bottom-change maps demonstrate that the 1987 to 1991 lake-bottom accretion or "bar" is essentially entirely within the present study area.

CH2M HILL Recommendation 3:

More detailed survey information is needed offshore between profiles N8030 and N8830 to determine the fate of the observed sand bar as it bends outward around Breakwater 6. The short-profiles should be extended, using hydrographic surveying techniques, from well inside the breakwaters out to the sand-clay interface.

Comment: Agreed. This need for expanded survey was previously stated in the comment for Recommendation 2.

CH2M HILL Recommendation 4:

New data should be collected in front of the south revetment (between profiles N5617 and N6550) to determine if shoaling is occurring in this area as a result of renourishment of the southern shoreline.

Comment: Agreed. However, these new lines should be part of an expanded survey grid that collects bathymetric data along the entire perimeter of the project, not just lakeward of the south revetment. This need for expanded survey was previously stated in the comment for Recommendation 2.

CH2M HILL Recommendation 5:

To ease the survey process (including underwater photography), we recommend that future efforts be conducted only when waves have been less than 1 foot for a period of 1 week or more. This increases the likelihood that the beach profiles are in stable equilibrium and that water clarity is maximized.

Comment: It is important to have the beach profiles in equilibrium and to have water clarity for photography. However, waiting for waves to be less than 1 foot for 1 week or more may not be logistically possible. Calm water is needed for the fathometer surveys; underwater photography should be done at optimum conditions during the time frame for survey operations.

Several other recommendations are here made by ISGS for future monitoring and reporting:

1. Diver survey and possible sand probings are needed to resolve question about the location of the sand/glacial till interface south of the project across the nearshore zone crossed by profiles N5067 to N4467.
2. Survey data of nearshore sand thicknesses and distribution from the above-mentioned area should be evaluated to determine if in fact lake-bottom changes since 1989 warrant extension of the survey grid farther southward.
3. Annual monitoring reports should specifically present annual profile comparisons and contour maps showing lake-bottom changes within each of the four beach cells, and annual volumetric change for each cell.
4. All fathometer data should be collected during conditions of flat water.
5. All profile data collected with prism pole should use a pole with a "plate-like" base to assure minimal subsidence in the fine-sand bottom, particularly along the more lakeward extent of the profile lines.

CONCLUSIONS

It must be emphasized that the 1991 data collection at Forest Park Beach is only the first year of a five-year monitoring program. Evaluation of the impact of the project on local littoral processes, identification of mitigation needs, and quantification of beach and nearshore changes are all factors that must await additional data collection in the four remaining years of this monitoring program.

The prime role of ISGS during the 1991 monitoring program at Forest Park Beach was to act as an independent observer and reviewer of data collection and data presentation by the consultant for the City of Lake Forest. This report by ISGS does not supplement or supercede the final report for 1991 monitoring prepared by CH2M HILL. This report is a synthesis of data checks, data evaluation and independent data collection and processing by ISGS for the purpose of verifying that the 1991 monitoring data are accurate, reproducible and valid. The following conclusions are drawn from the review and study by ISGS:

- 1) The 1991 survey grid at Forest Park Beach established by CH2M HILL is accurate, reproducible, and valid for reference during the future collection of monitoring data.
- 2) Based on the representative data comparisons by ISGS, the 1991 beach and nearshore wading data (short profiles) collected at Forest Park Beach and reported by CH2M HILL are accurate, reproducible, and valid for comparison against future monitoring data.

- 3) Based on the representative data comparisons by ISGS, the 1991 fathometer data (long profiles) collected at Forest Park Beach and reported by CH2M HILL are valid for comparison against future monitoring data, but it must be understood that these fathometer data have been smoothed to eliminate boat motions and this procedure has also eliminated irregularities actually present across the glacial-till surface.
- 4) Additional bathymetric data are needed to extend to a distance of 600 feet from the preconstruction shoreline along the entire perimeter of Forest Park Beach. Only then will it be possible to accurately evaluate the areal extent, depth range, geomorphology and volume of the subaqueous bar/accretionary prism which is related to bypass of littoral sediment around Forest Park Beach.
- 5) There is variance in the volume calculation for the "bar" on the updrift side of the project depending on the areal extent of accretion used in the volume calculation. Based on comparison of 1987 and 1991 bathymetry, and for nearshore accretion north of the second breakwater from the north (Breakwater V), the ISGS volume calculation for the nearshore accretion is 9,500 or 13,000 cubic yards depending on the accepted area of total nearshore accretion. This agrees with other volume estimates of 10,000 cubic yards by the Lake Forest Shoreline Monitoring Committee (1990a) and the $7,000 \pm 1,800$ cubic yards by CH2M HILL (1992). The overall agreement between estimates by ISGS, CH2M HILL and the Lake Forest Shoreline Monitoring Committee is that since the previous estimate there has not been any appreciable gain in volume for the nearshore accretion on the updrift end of the project.
- 6) Comparisons of 1987-1991 bathymetric data for the northern beach cell indicate that lake-bottom accretion has occurred causing decreased depths in the central area of the cell by as much as 3.5 feet. A volume estimate for the north-cell accretion is 3,500 cubic yards. Accretion has likely occurred in the second cell from the north but this was not evaluated in this 1991 ISGS study, nor were the southern two cells.
- 7) Although the Forest Park Beach project may have been a total or near-total barrier to littoral transport in early post-construction time, bypass is now occurring. The efficiency of bypass has yet to be evaluated. Evidence for bypass of the northern part of the project is an accretionary prism on the lakeward perimeter of the northern breakwaters, and a lakeward shift of the sand/glacial-till interface along the perimeter of the project.
- 8) The 3,000 cubic yards of beach nourishment supplied to the south side of the Forest Park Beach project in 1991 is a coarse sand according to the Udden-Wentworth grade scale. For three samples collected and analyzed

by ISGS, median diameters are 0.57mm, 0.57mm and 0.77mm. This nourishment sediment is coarser than surface sediments collected and analyzed by CH2M HILL from atop the updrift "bar", coarser than sediment from the lake-bottom accretion in the northern two beach cells, and coarser than sediment from these two beach cells along their breakwater centerlines.

- 9) The Illinois coast has had a long history in the building of structures and lakefills that have formed total or near-total barriers to littoral transport. The accurate design and limited lakeward protrusion of the Forest Park Beach project limits the project's potential impact as a littoral barrier and facilitates natural bypass. The project is also along a reach of the Illinois coast with "lean" supply of littoral sediment, and interacts with the limited littoral sediment supply along the 3.5 mile reach south of the harbor at Great Lakes Naval Training Center.
- 10) The ISGS is in overall agreement with recommendations reported by CH2M HILL to improve future monitoring at Forest Park Beach.

ACKNOWLEDGEMENTS

Special appreciation is extended to the City of Lake Forest parks, engineering, and police departments for the courtesy and cooperation extended to the personnel of the Illinois State Geological Survey (ISGS) during field work and site visits at Forest Park Beach. The City of Lake Forest engineering department was particularly helpful in providing copies of maps, electronic Geographic Information System (GIS) map files, survey records, and aerial photography. ISGS personnel assisting in the field studies at Forest Park Beach were Dan Van Roosendaal and Paul D. Terpstra. Christopher Rompot assisted with the data processing and computer plotting of the profiles. Paul D. Terpstra completed digital bathymetric maps and lake-bottom change maps.

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APPENDIX A

Comparison of ISGS Fathometer Traces for August 12 and October 09, 1991

EXPLANATION

The following are photo-reduced copies of the ISGS fathometer strip-charts for a distance of 1,804 feet (550 meters) from the profile control point.

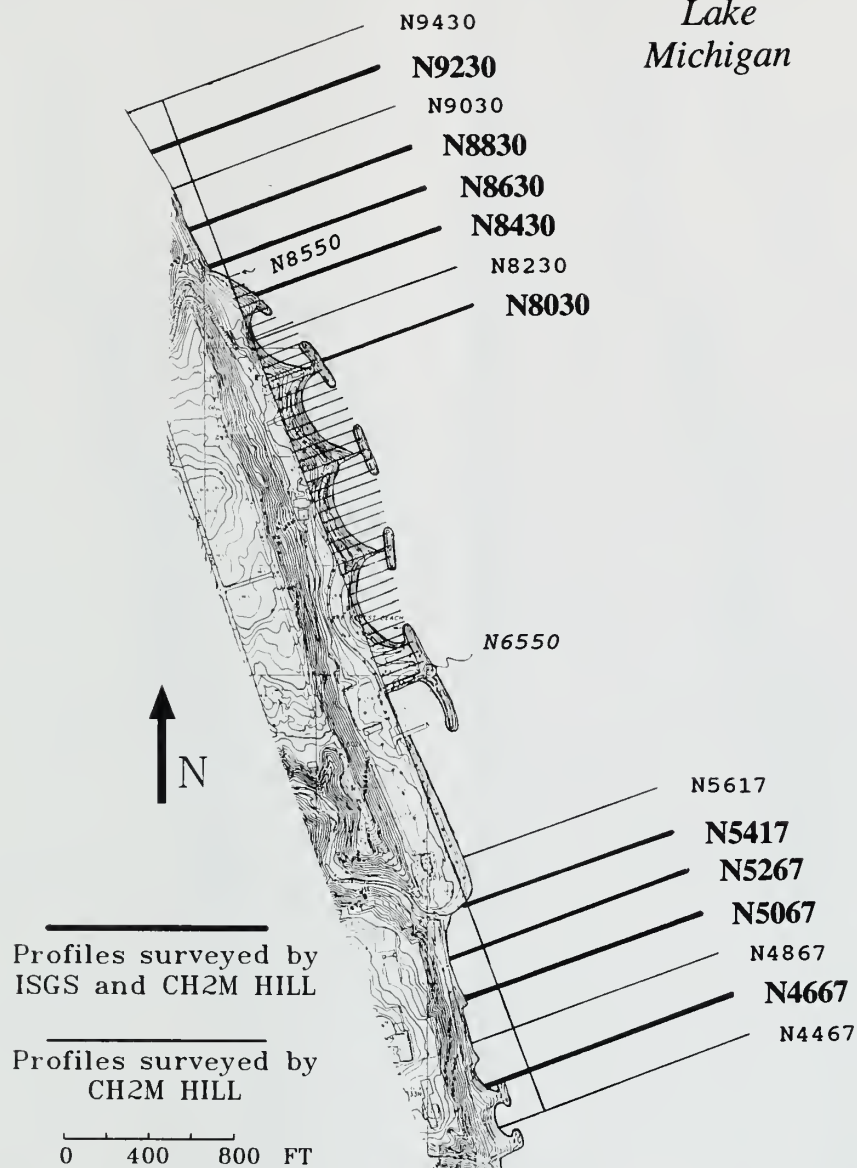
Lines across the fathometer trace are event marks corresponding to 32.8 ft (10 meter) increments as displayed on the console for the Motorola Mini-Ranger III.

Difference in distance on the two strip charts is caused by difference in boat speed (slightly faster boat speed for October 09).

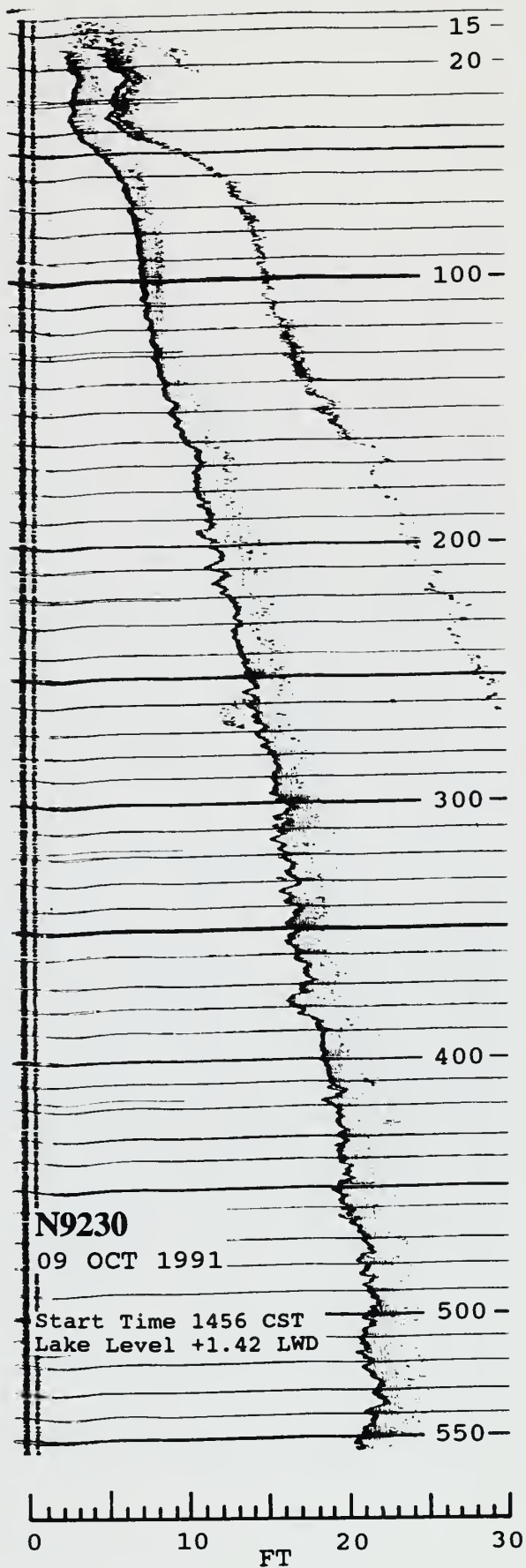
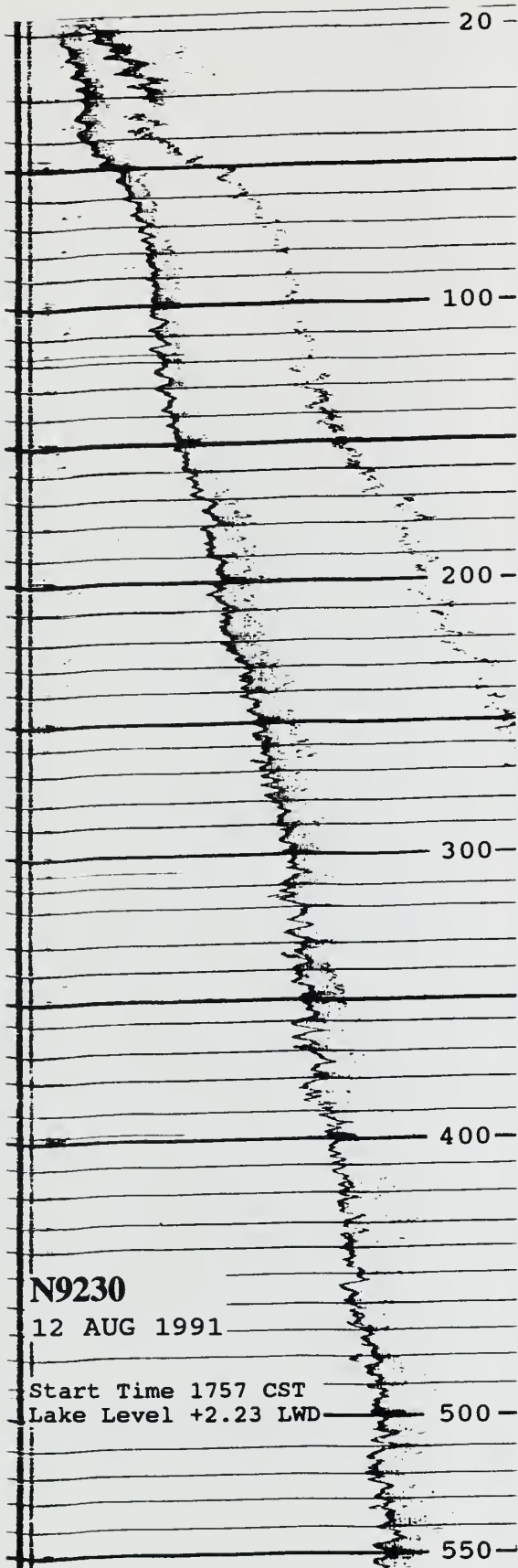
The August 12 lines were run during 1 to 2 foot waves (3 to 4 sec period); the October 09 lines were run during calm water.

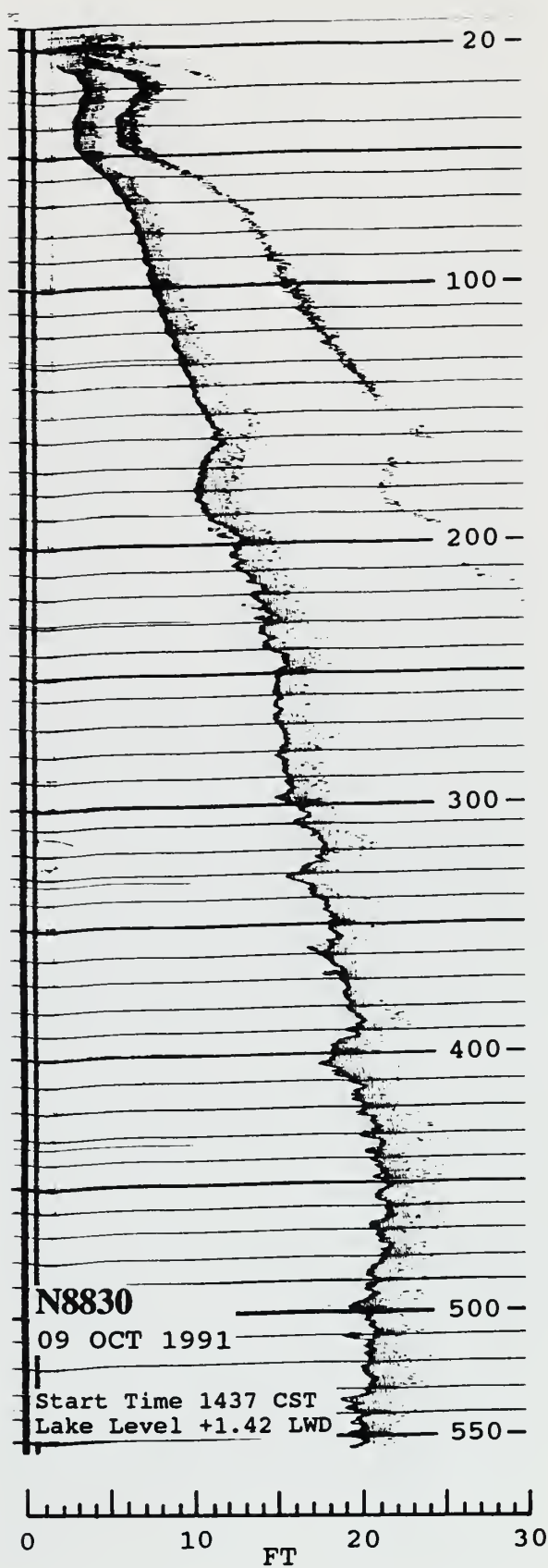
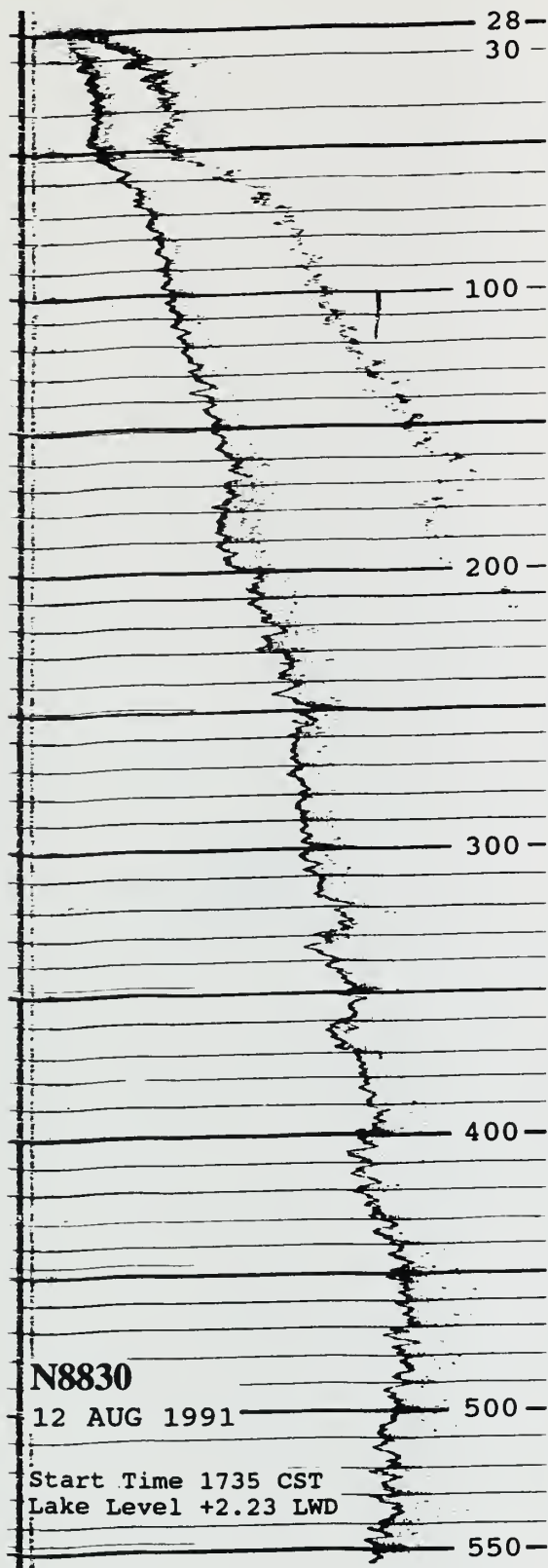
Depth is recorded in feet referenced to the lake level at the time of the survey.

*Lake
Michigan*

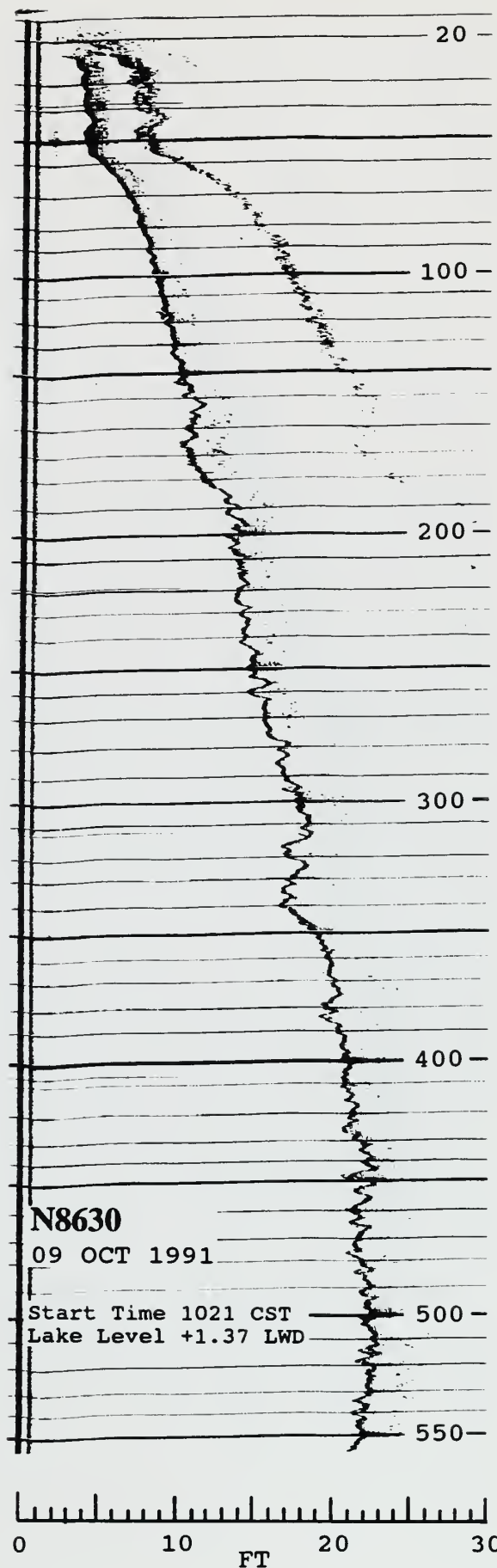


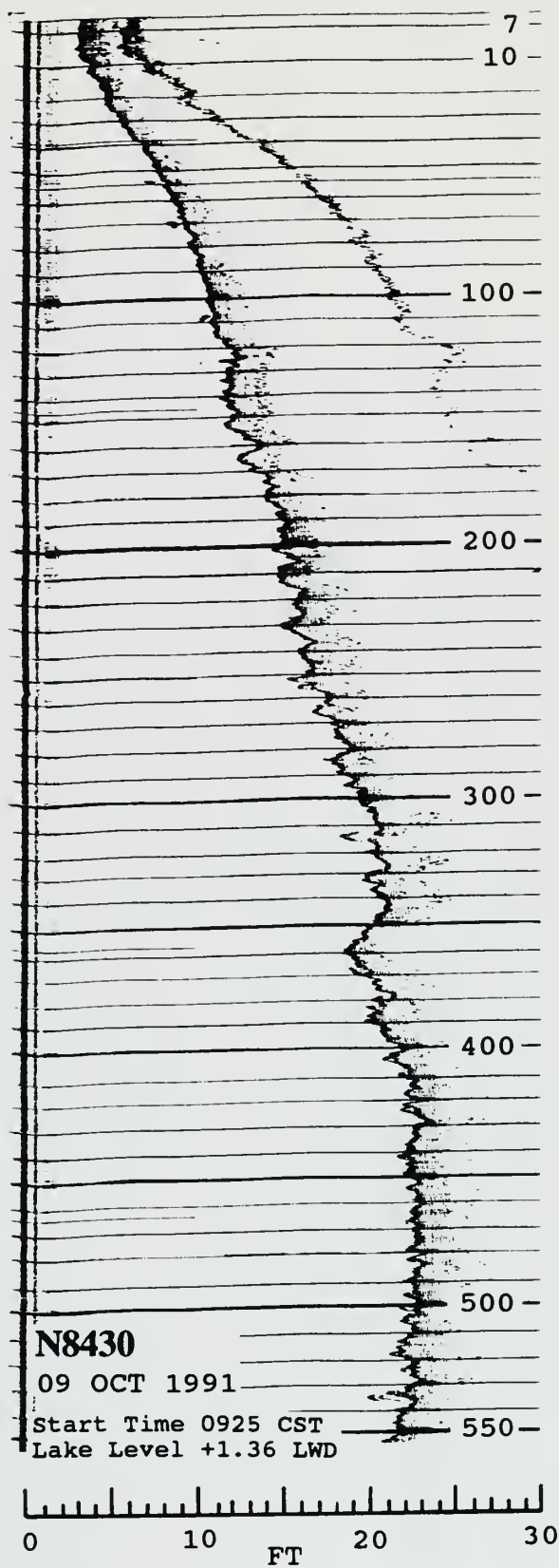
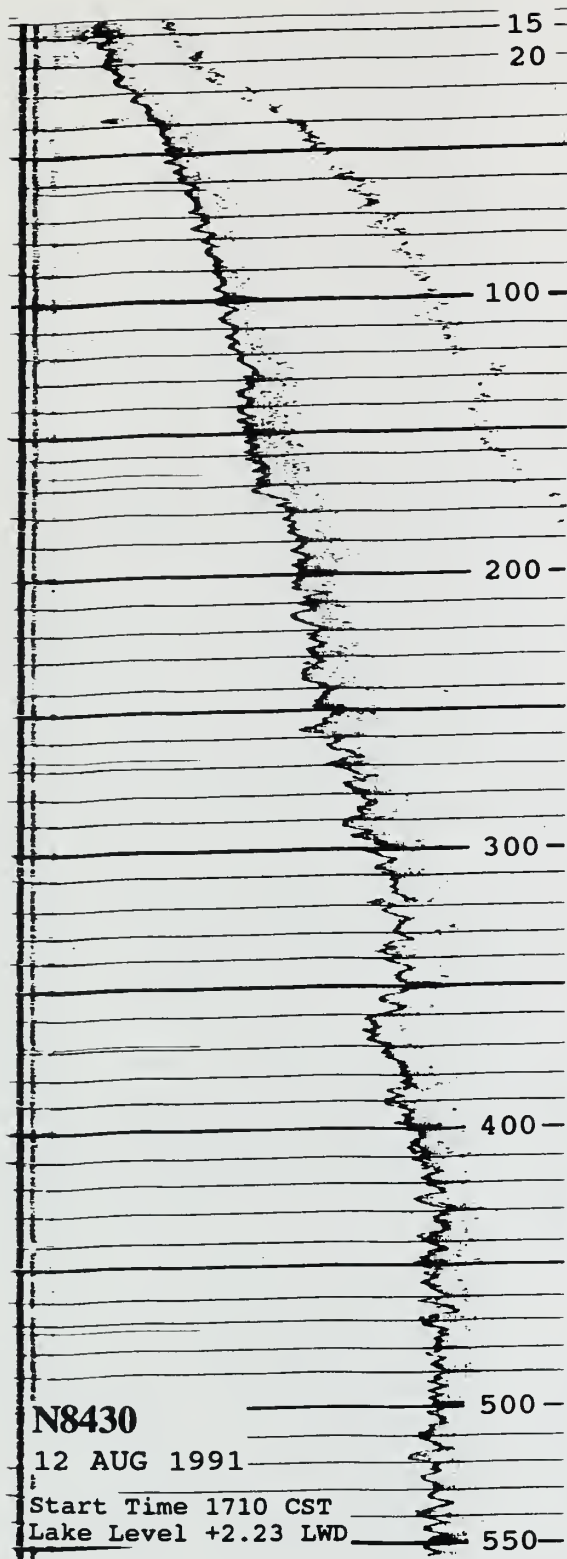
INDEX MAP FOR APPENDIX A

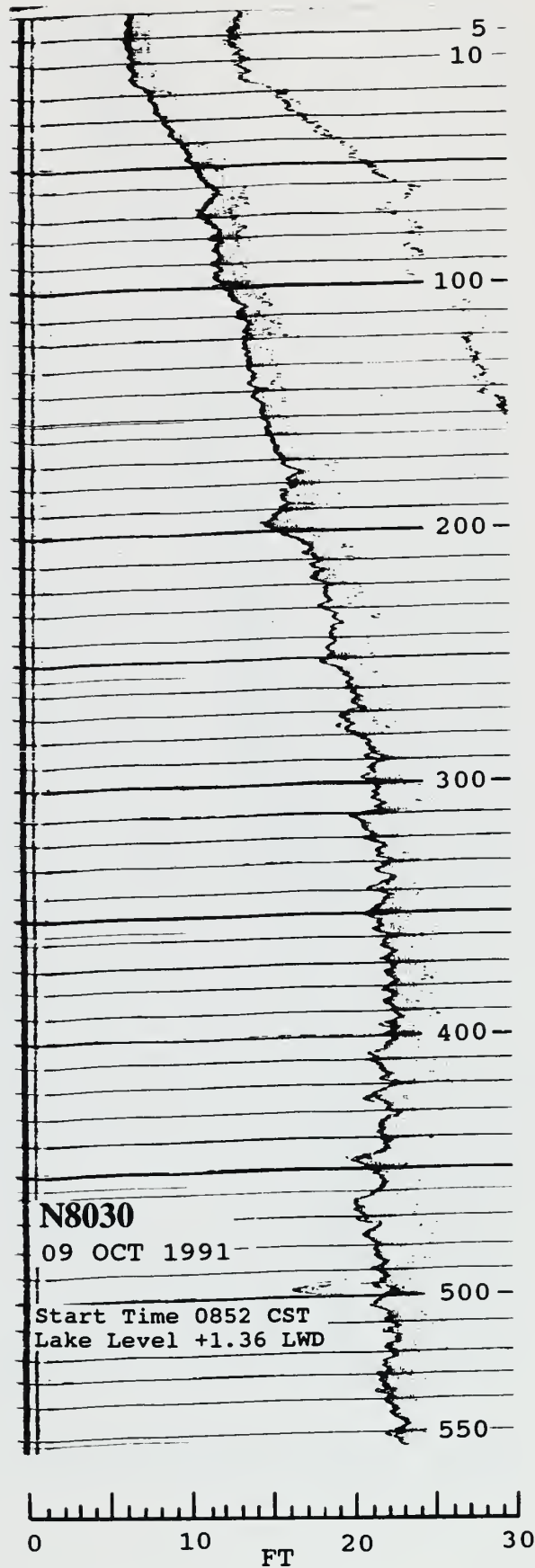
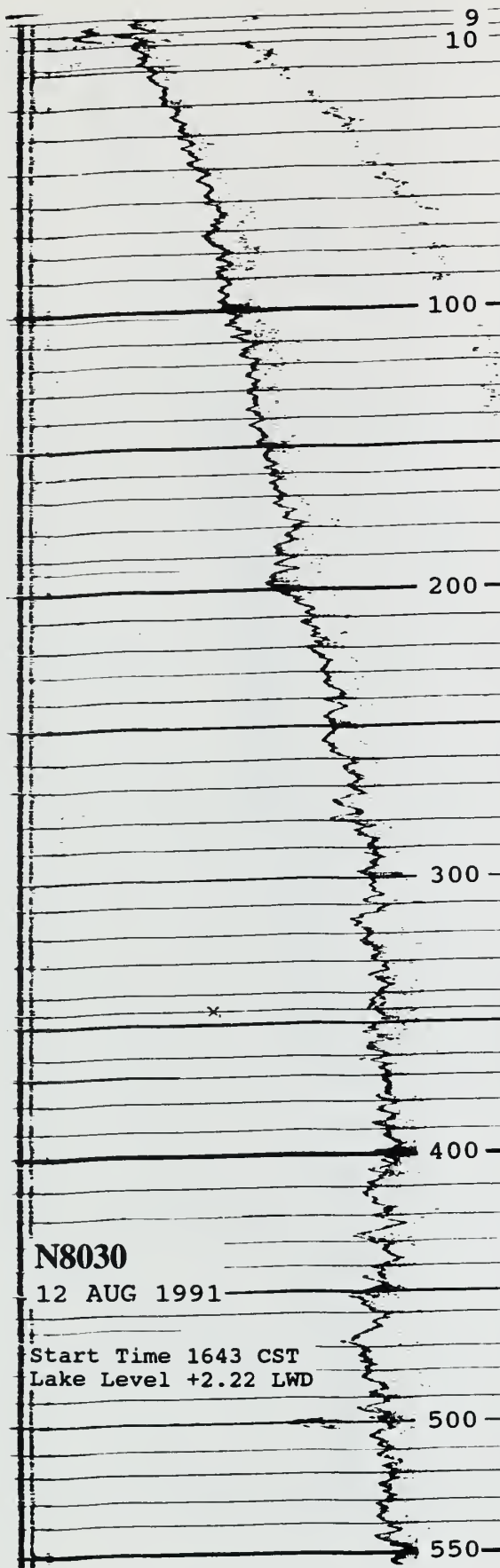


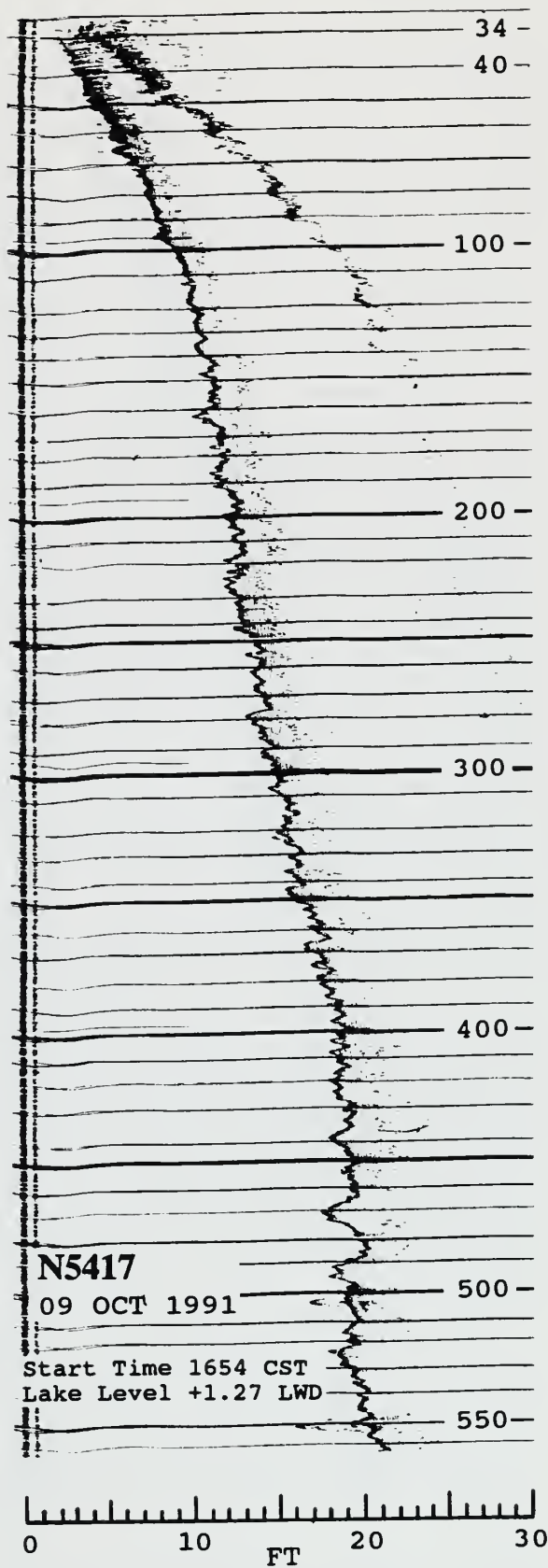
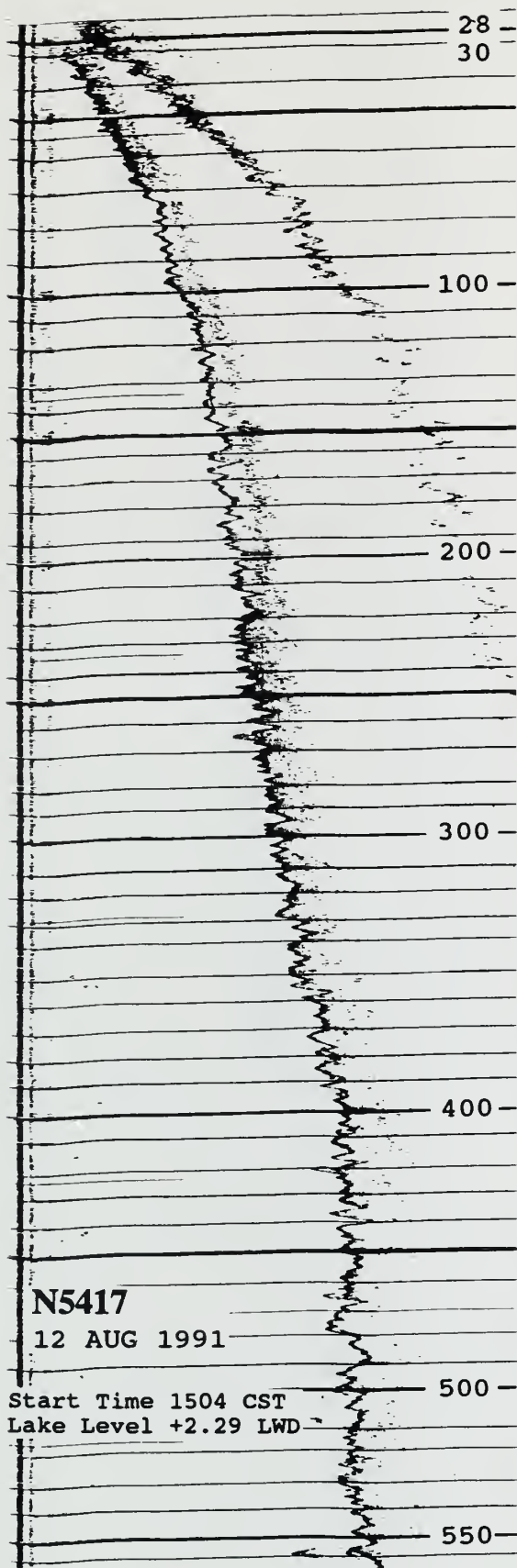


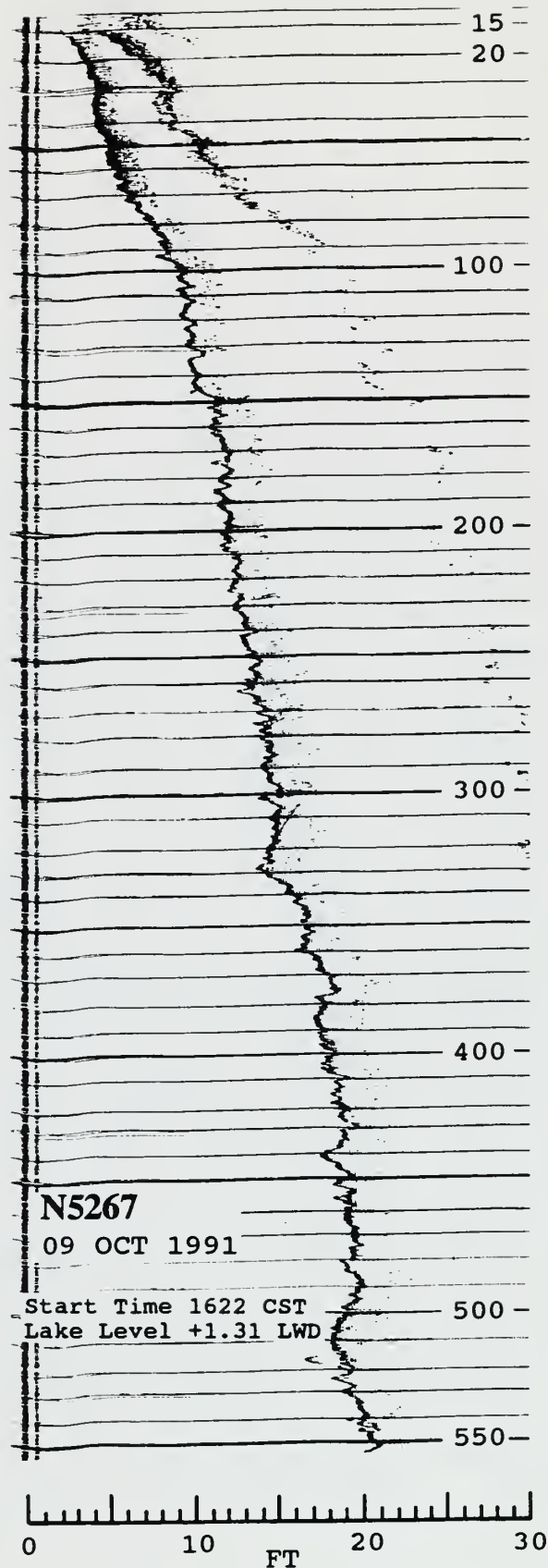
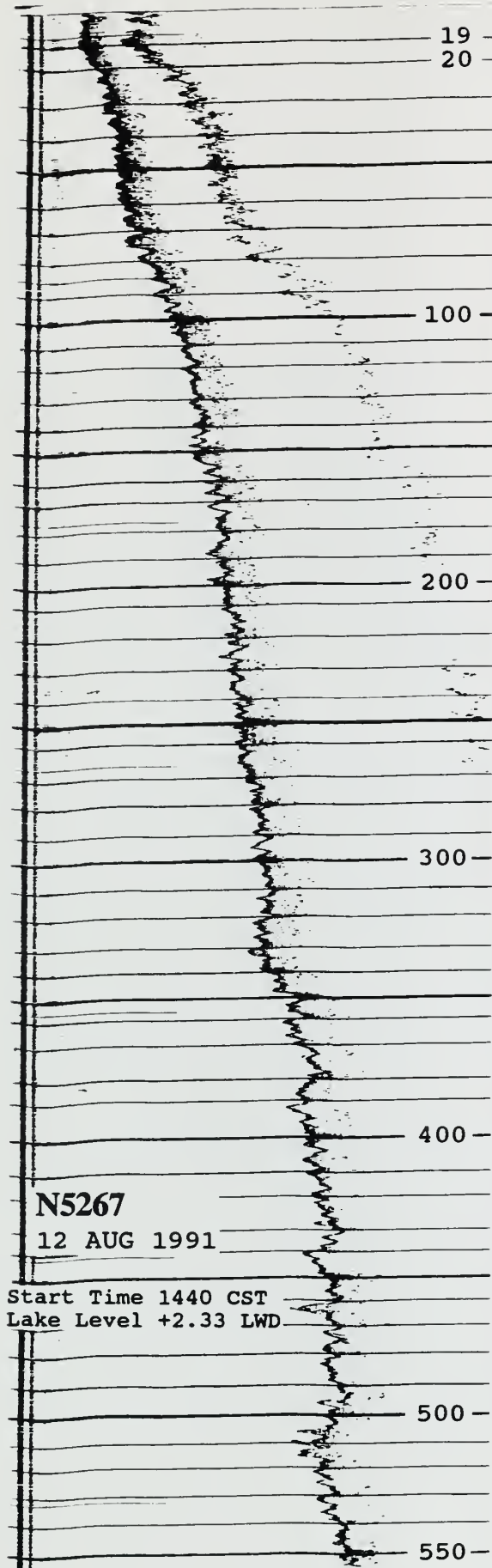
N8630
not surveyed on
12 AUG 1991

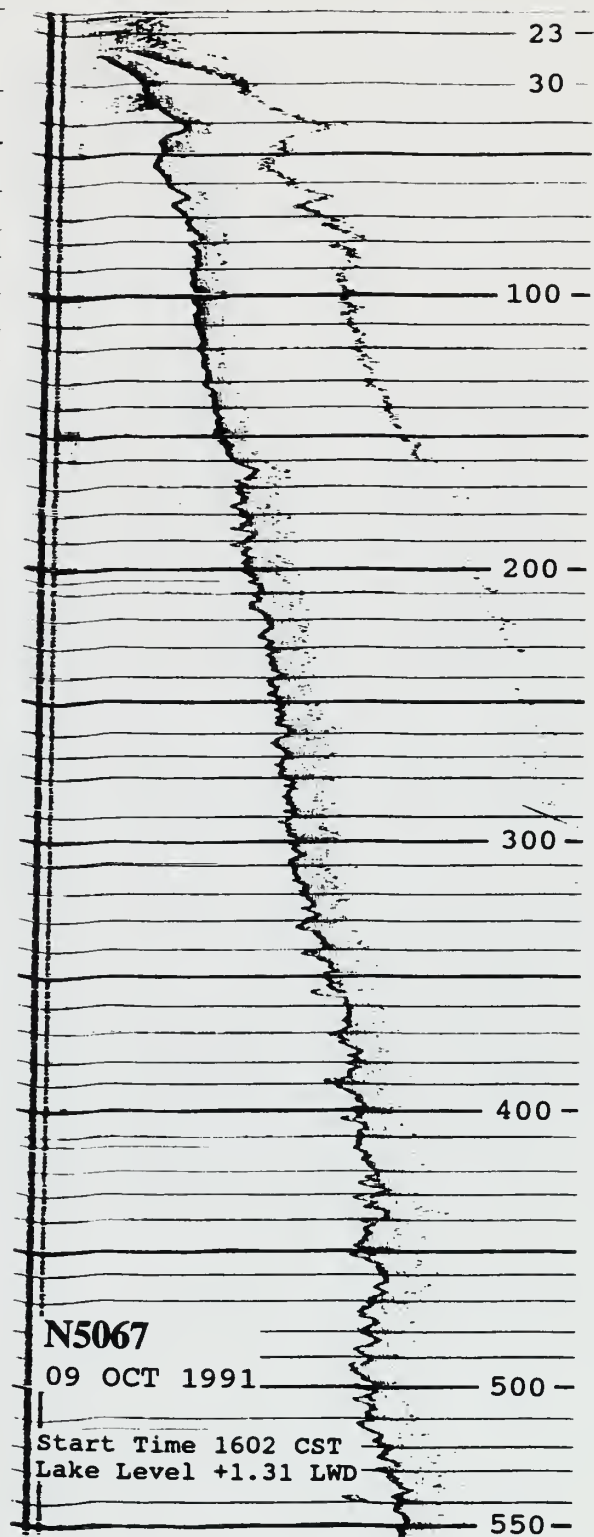
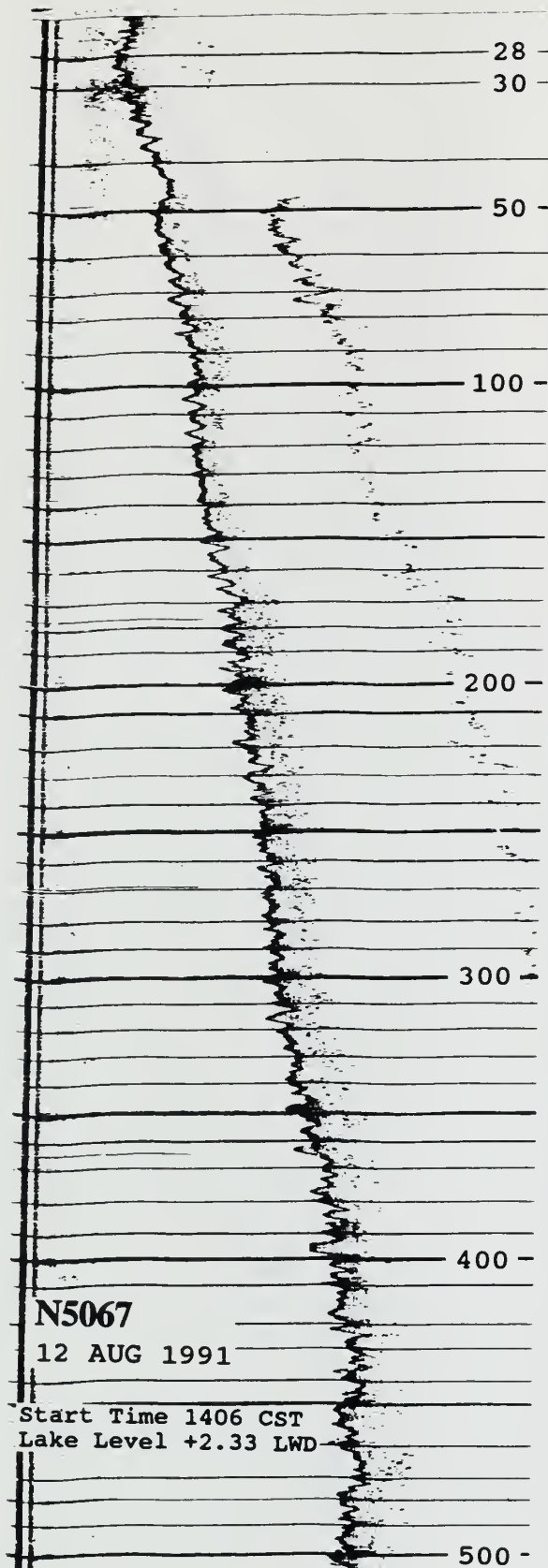


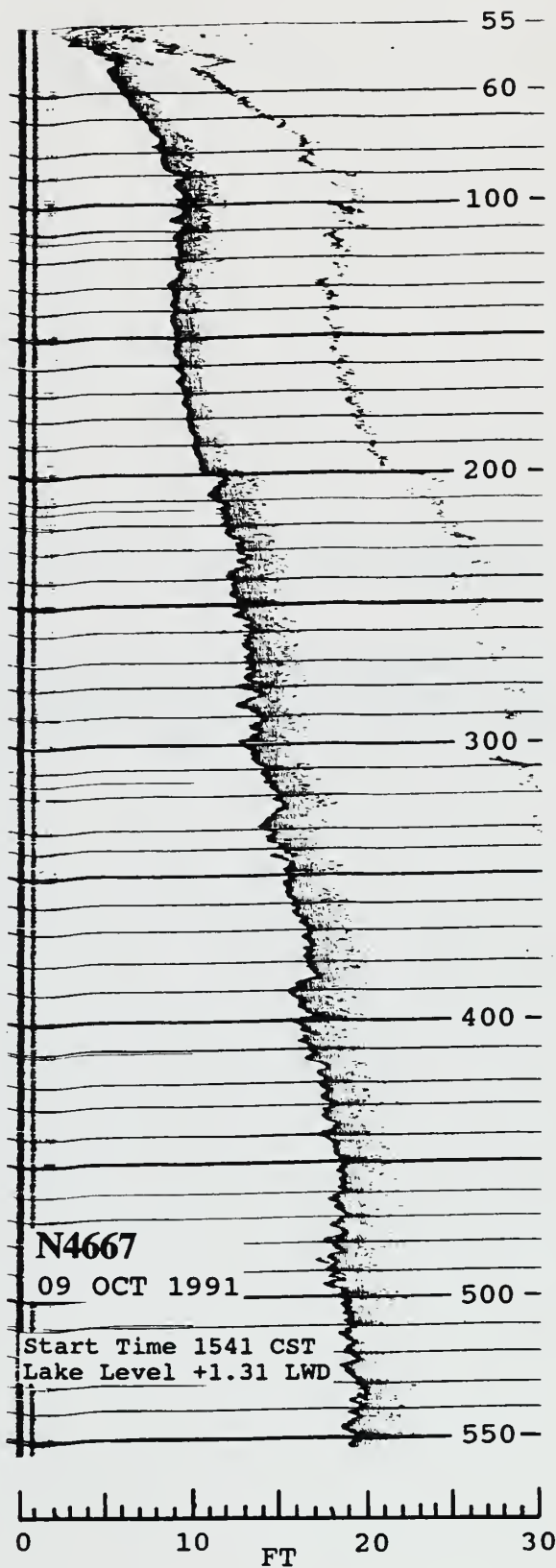
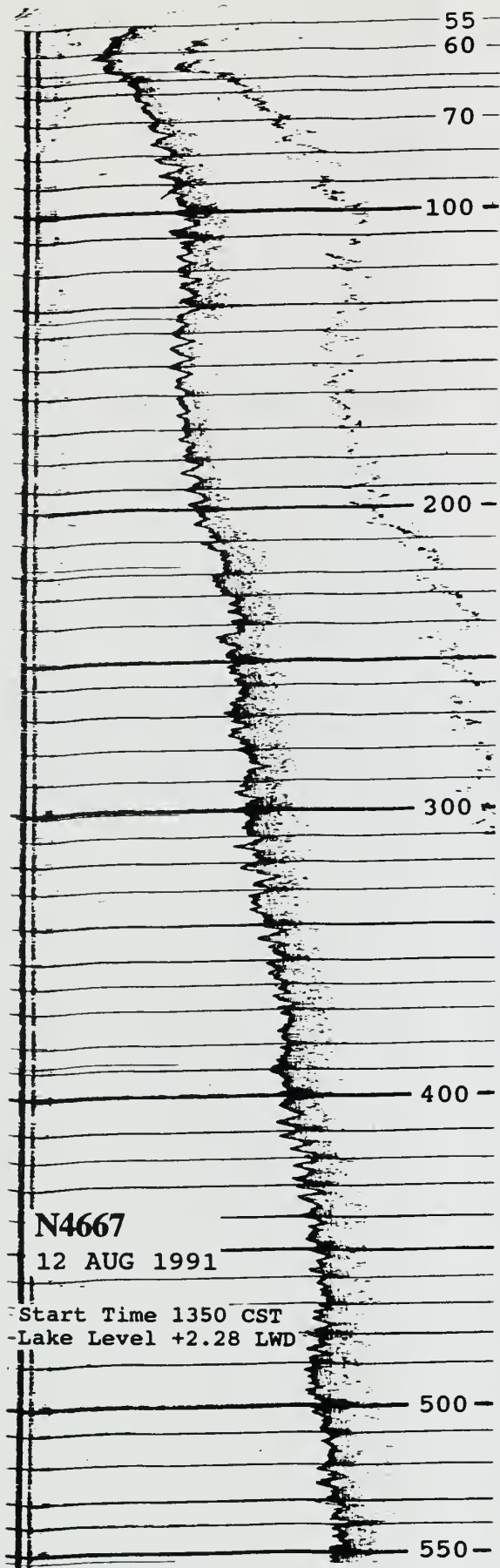












APPENDIX B

Comparison of ISGS and CH2M HILL 1991 Fathometer (Long) Profiles

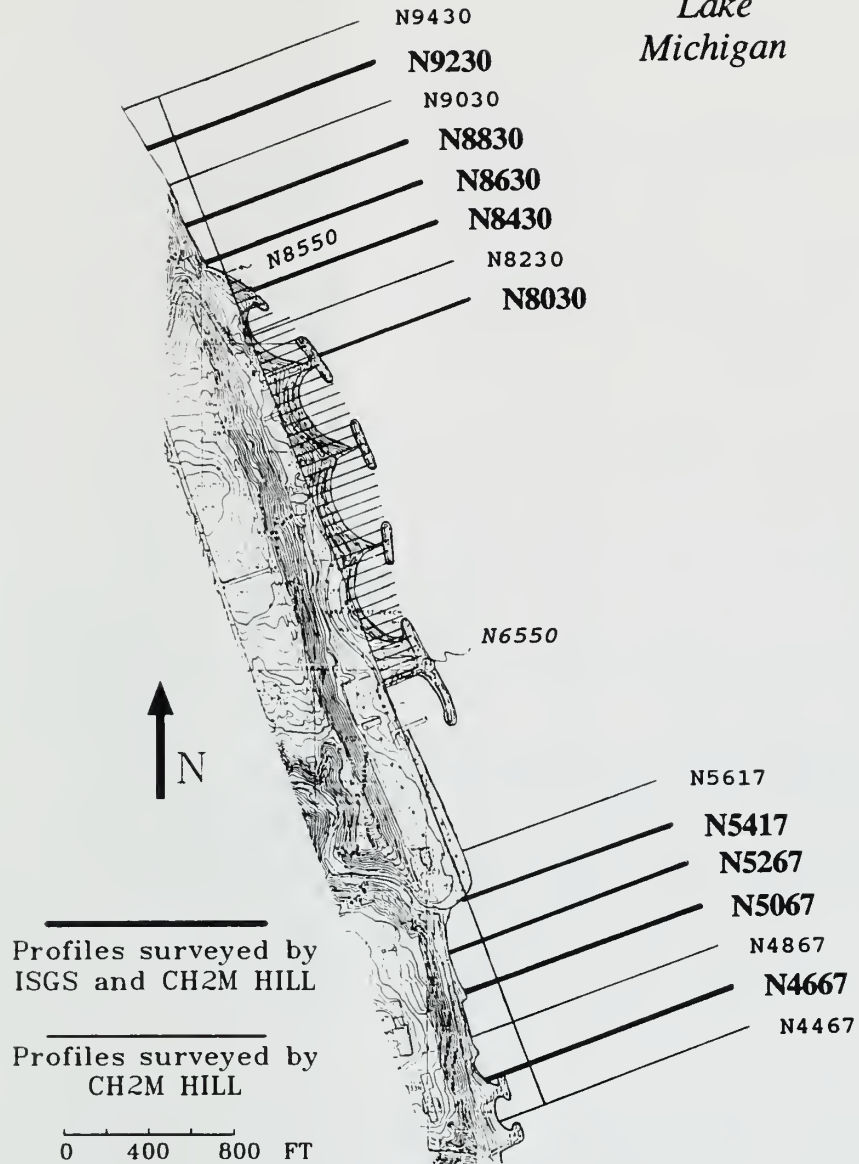
EXPLANATION

Three profiles presented in stacked arrangement are:

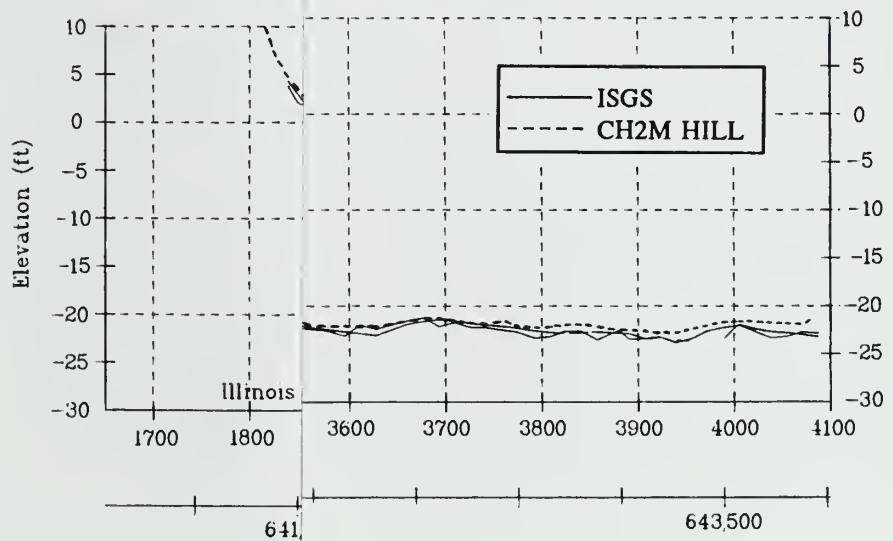
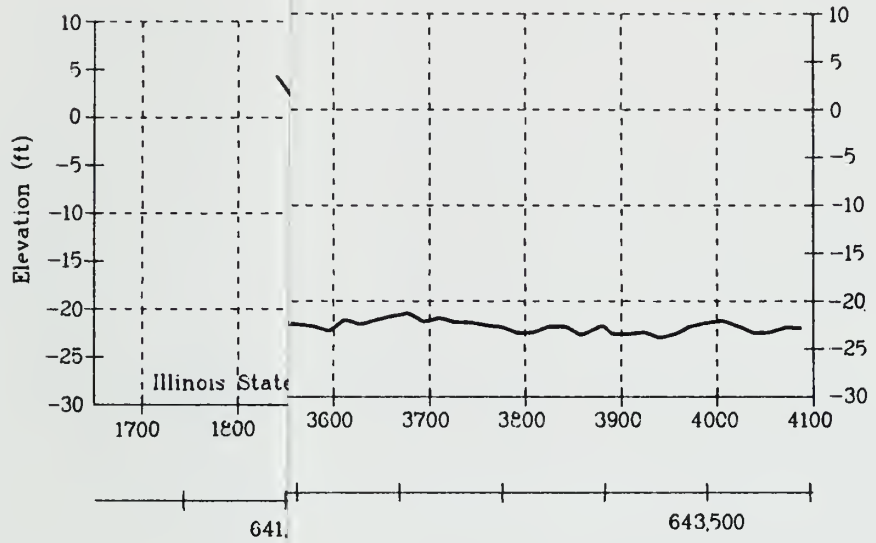
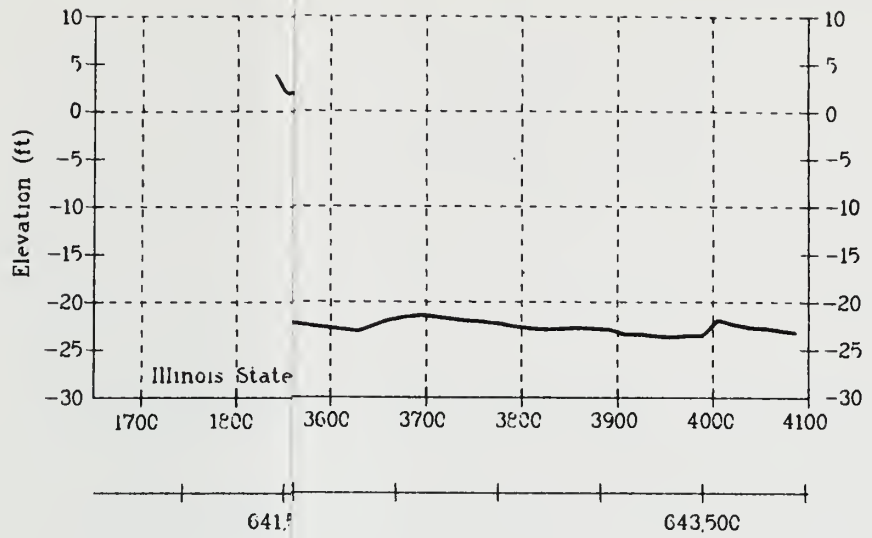
- A) ISGS profile for August 12, 1991
- B) ISGS profile for October 09, 1991
- C) Comparison of ISGS profiles for August 12/October 09 and CH2M HILL profile for August 12 or 13, 1991

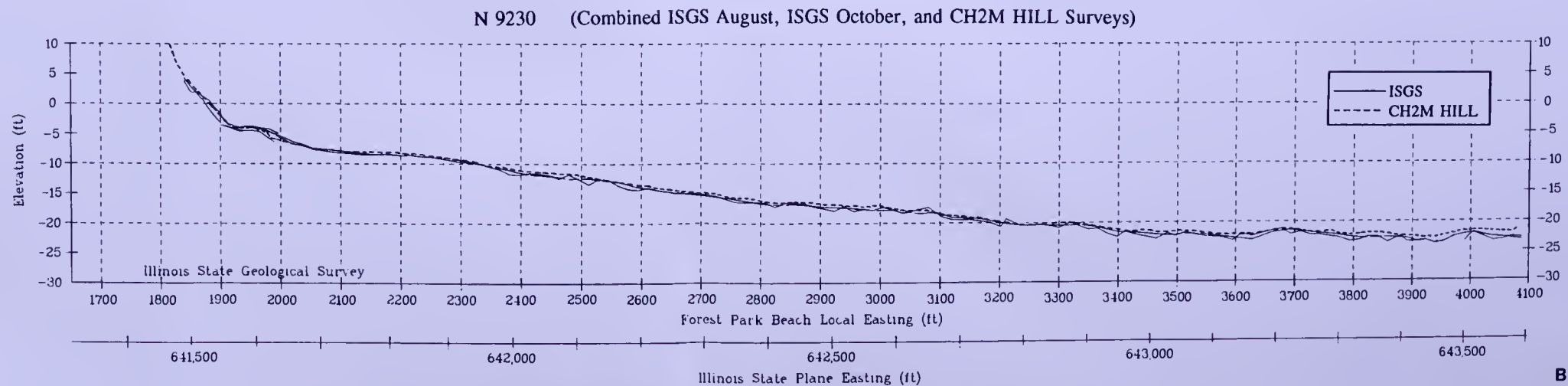
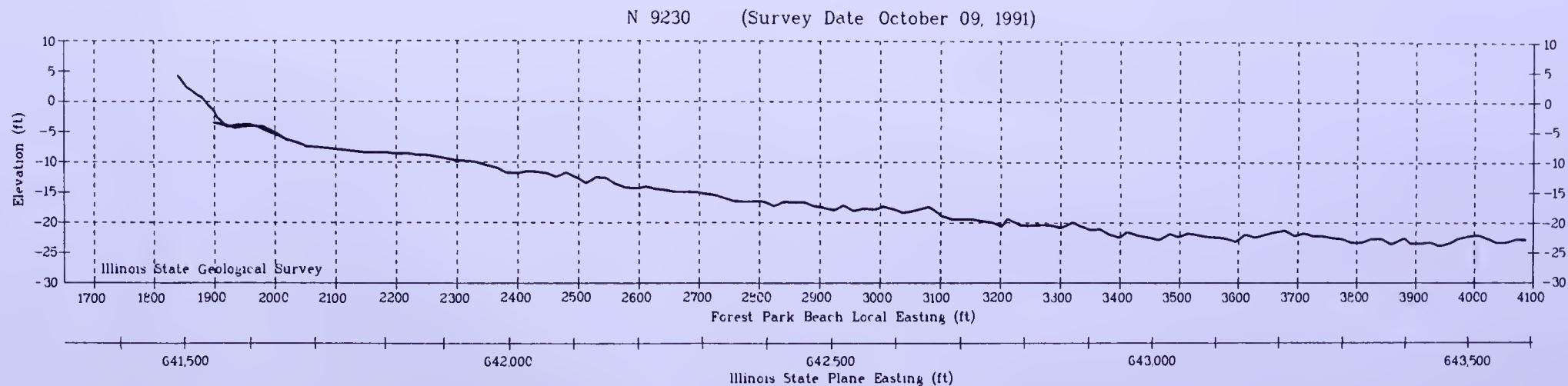
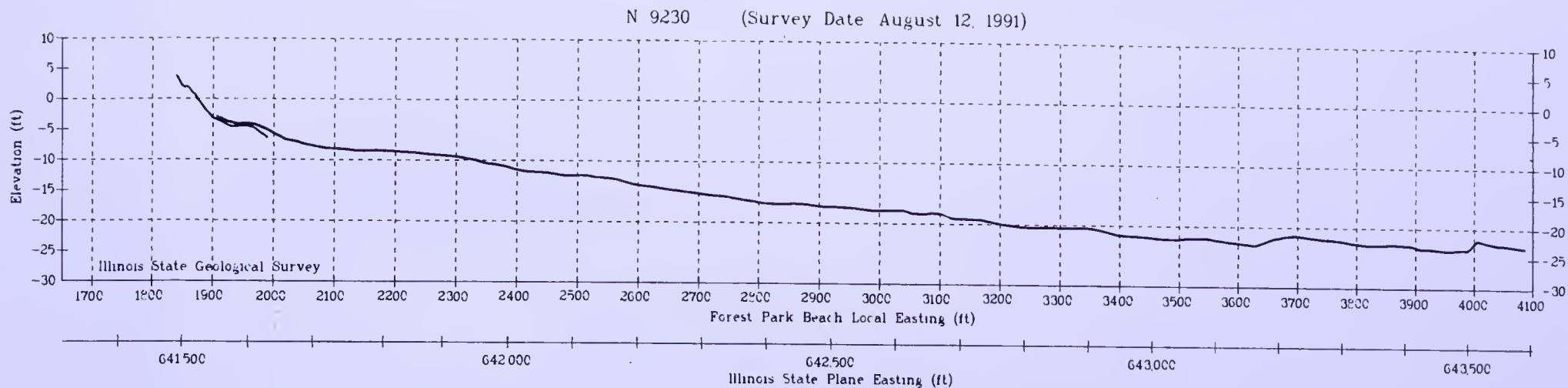
Elevations are referenced to Lake Forest Datum (LFD). Vertical exaggeration for all profiles is 10x. Distinction of the ISGS August and October profiles in the comparison with the CH2M HILL profile requires a visual cross reference to the individual profiles above the comparison.

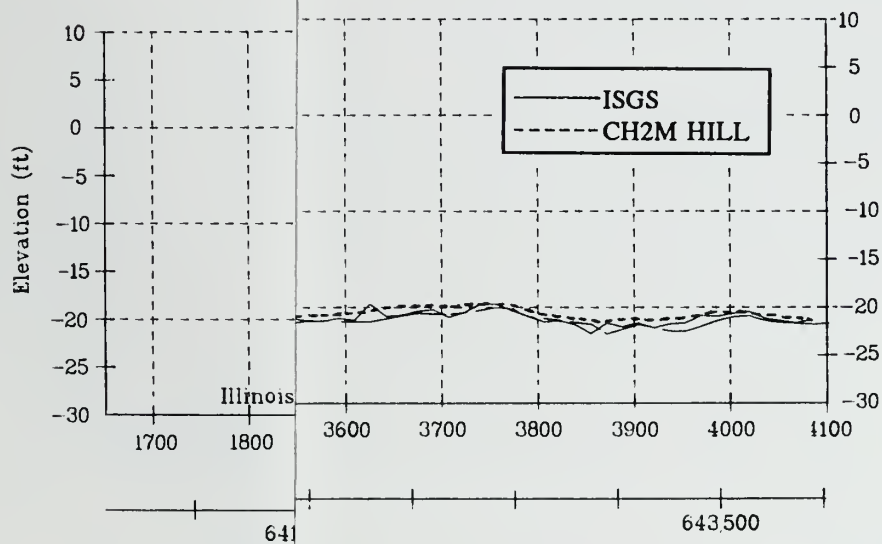
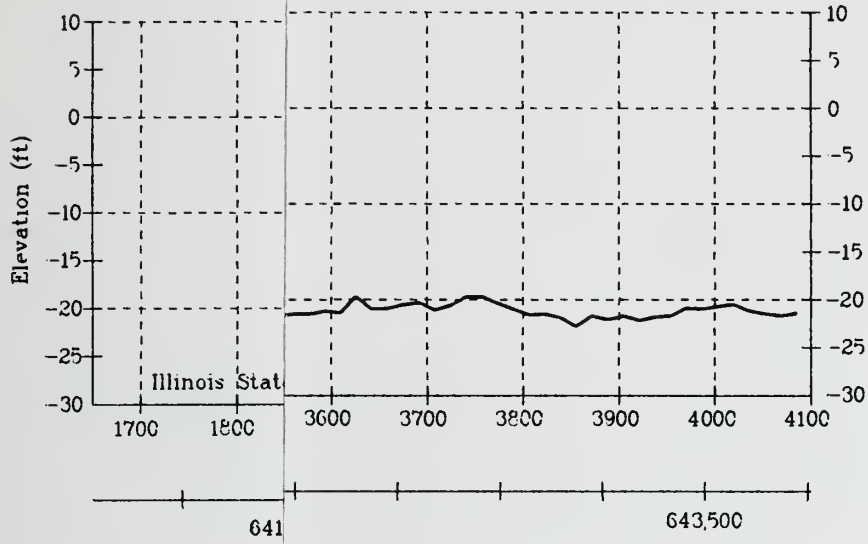
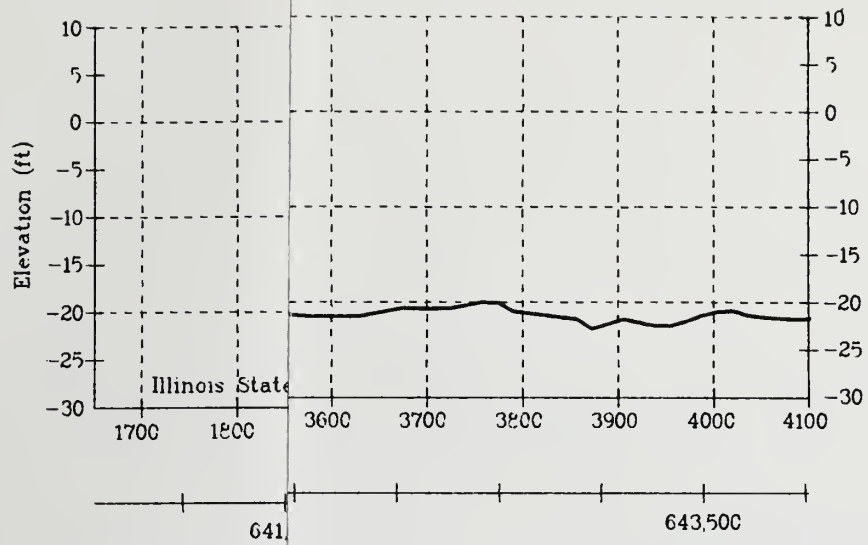
*Lake
Michigan*



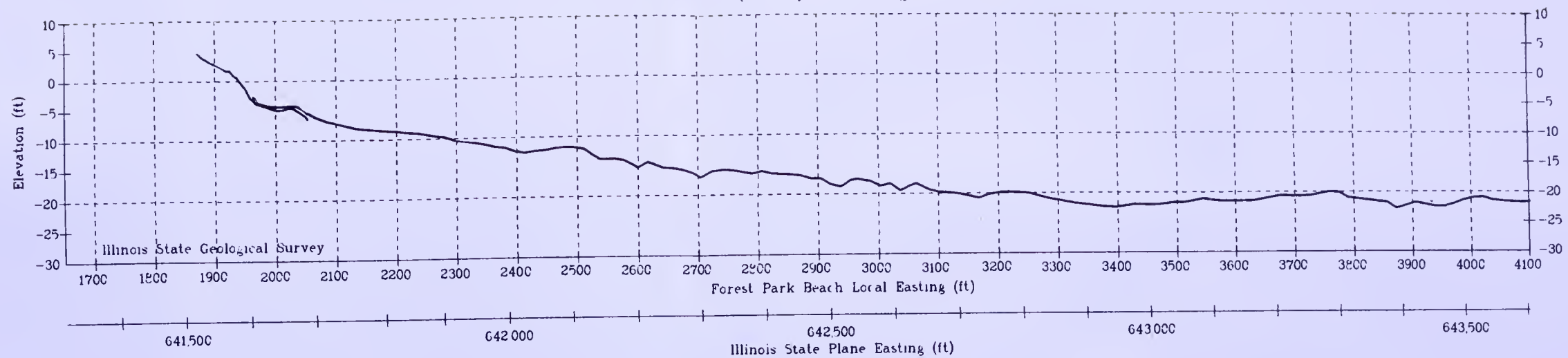
INDEX MAP
FOR APPENDIX B



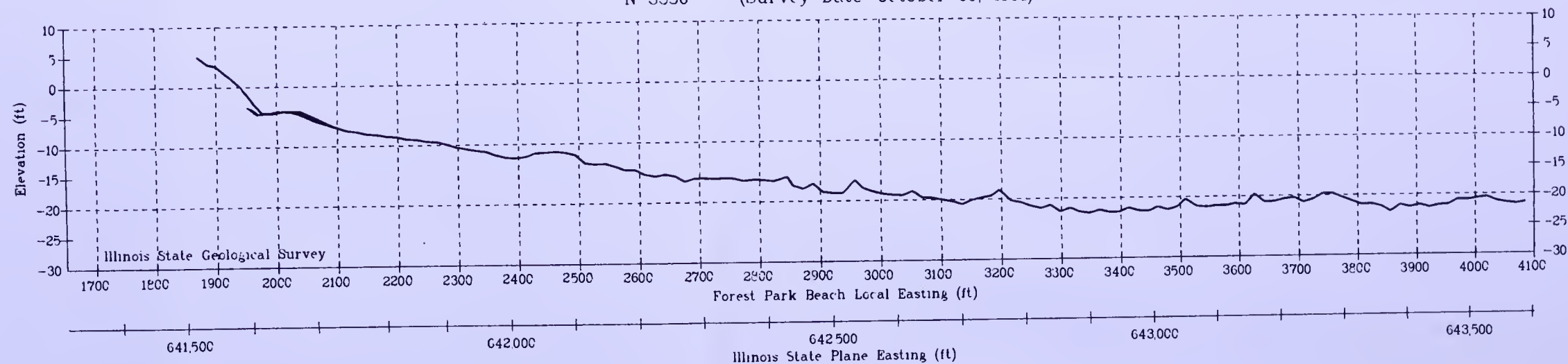




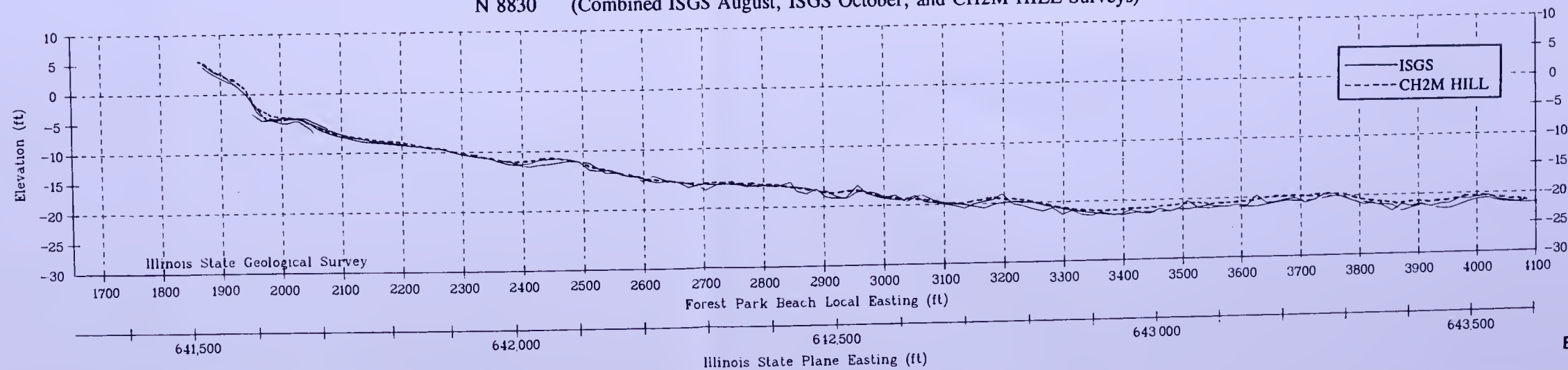
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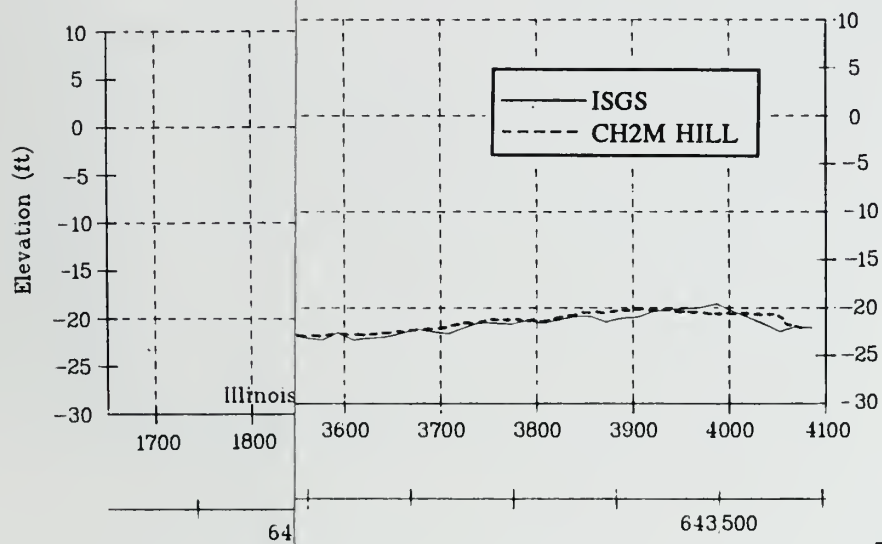
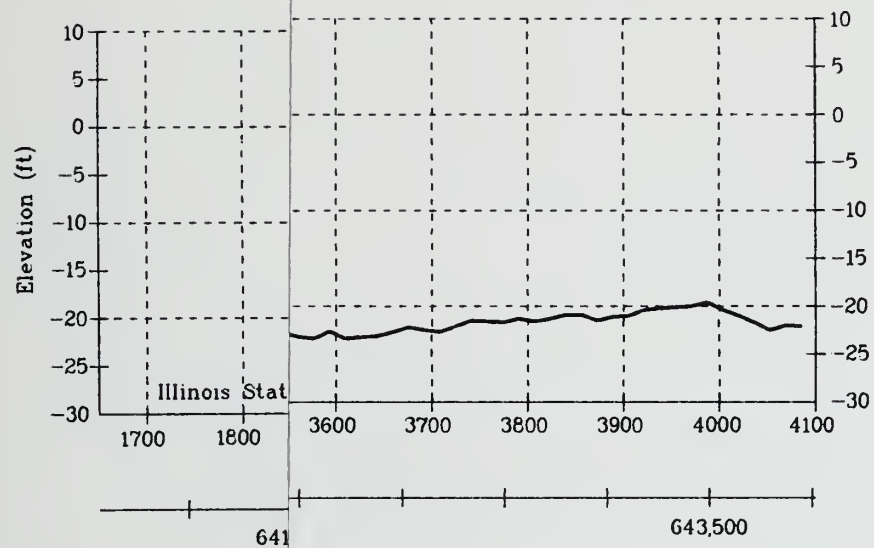


N 8530 (Survey Date October 09, 1991)



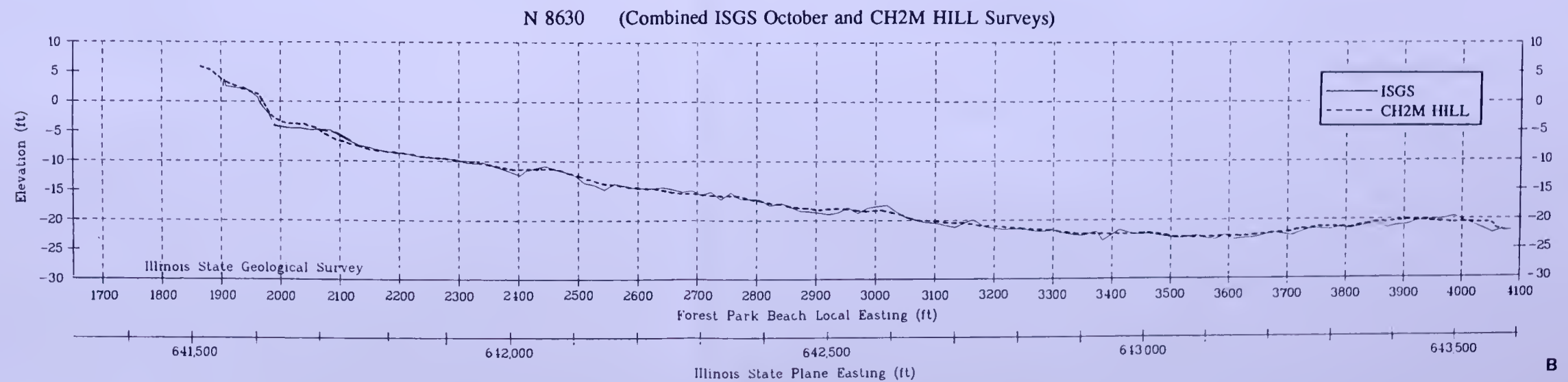
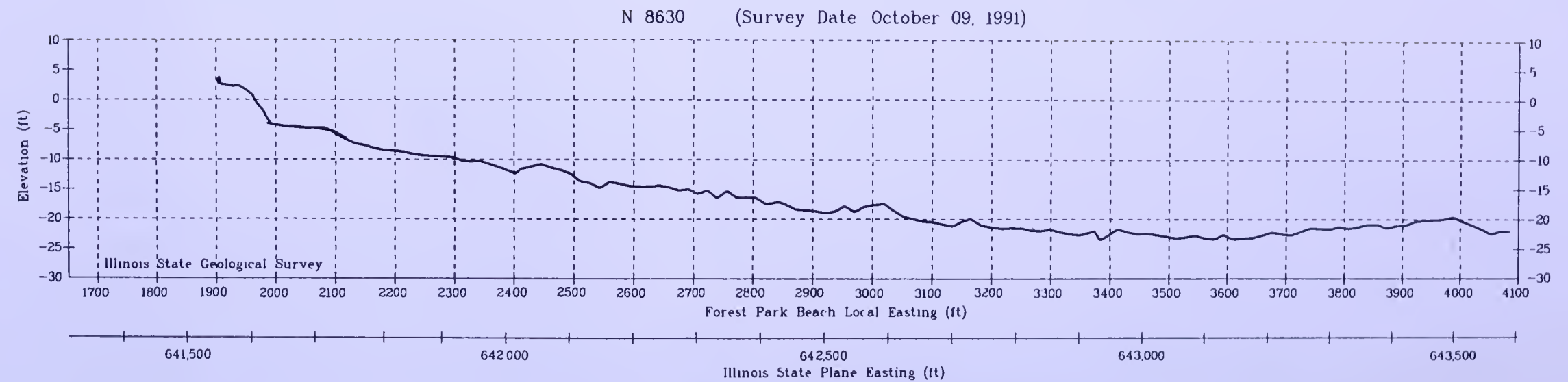
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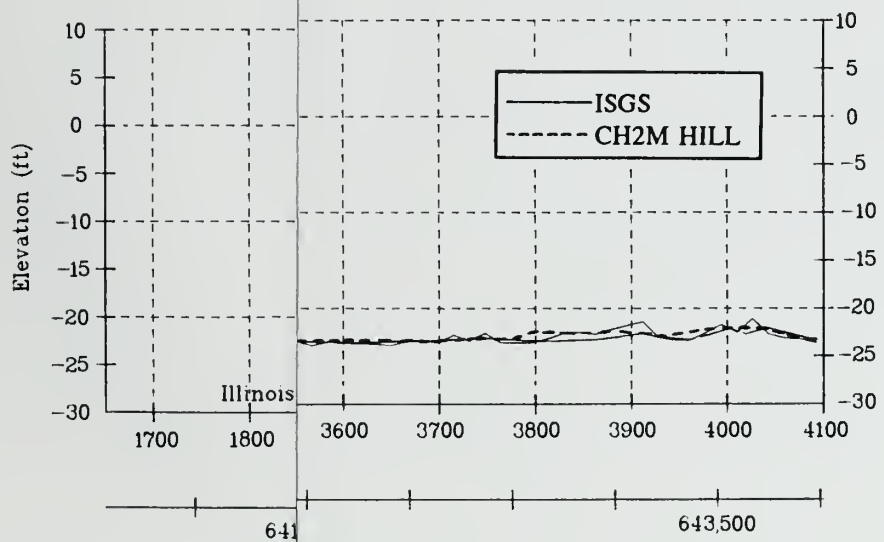
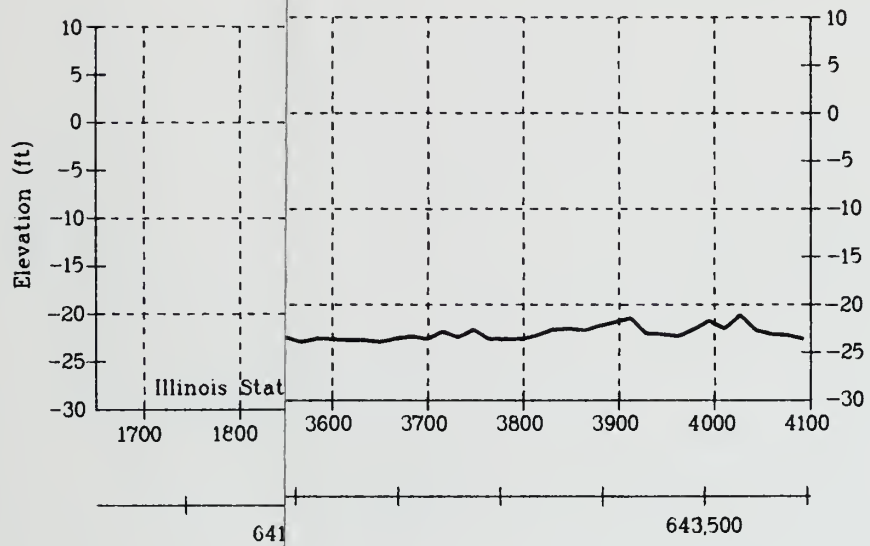
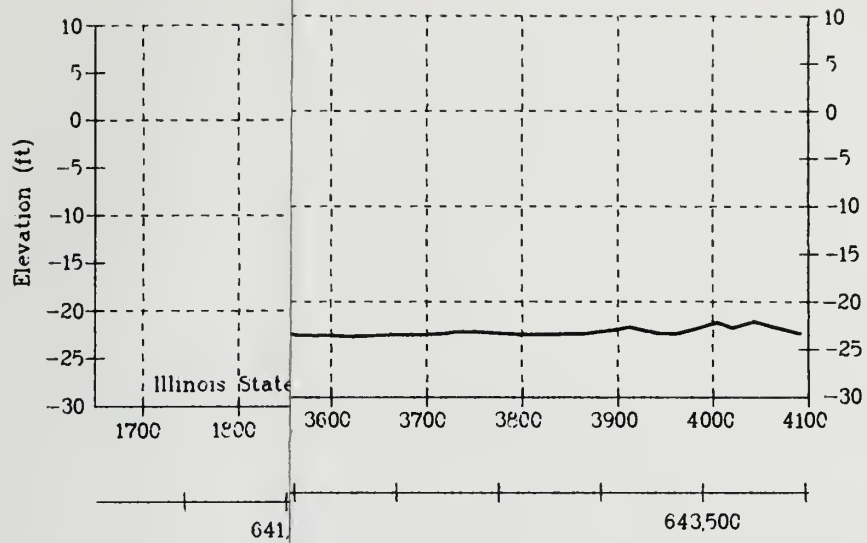


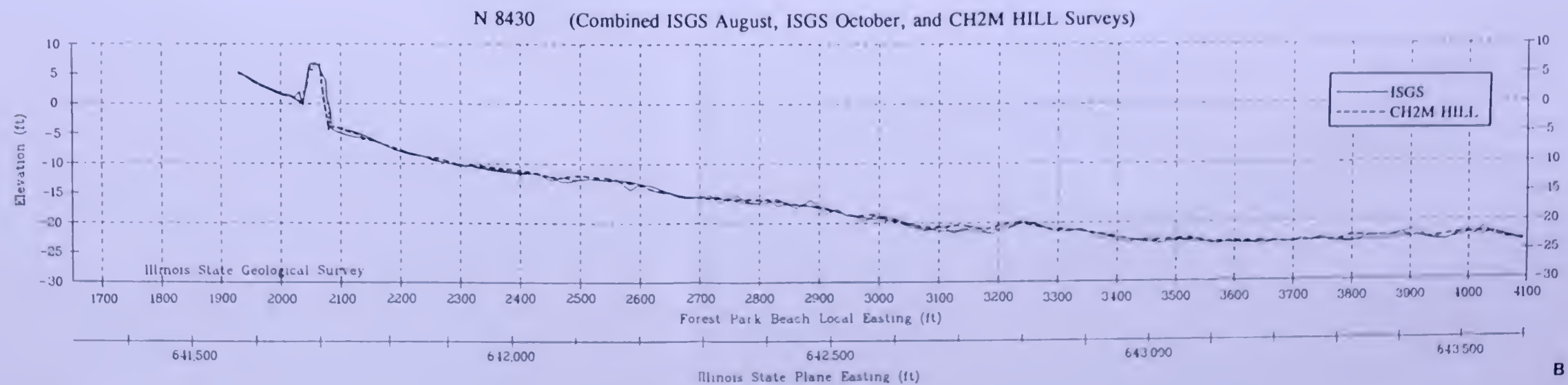
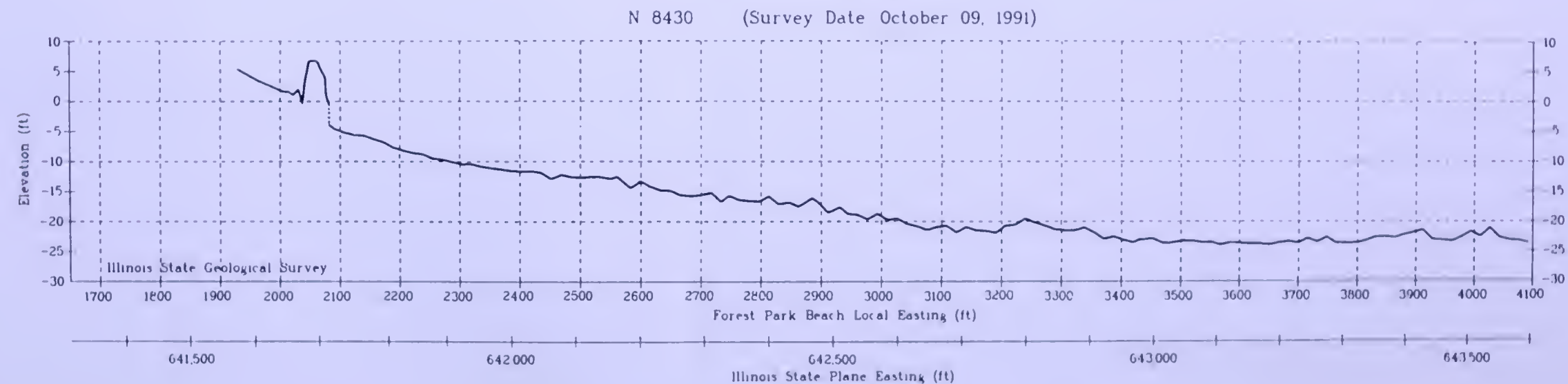
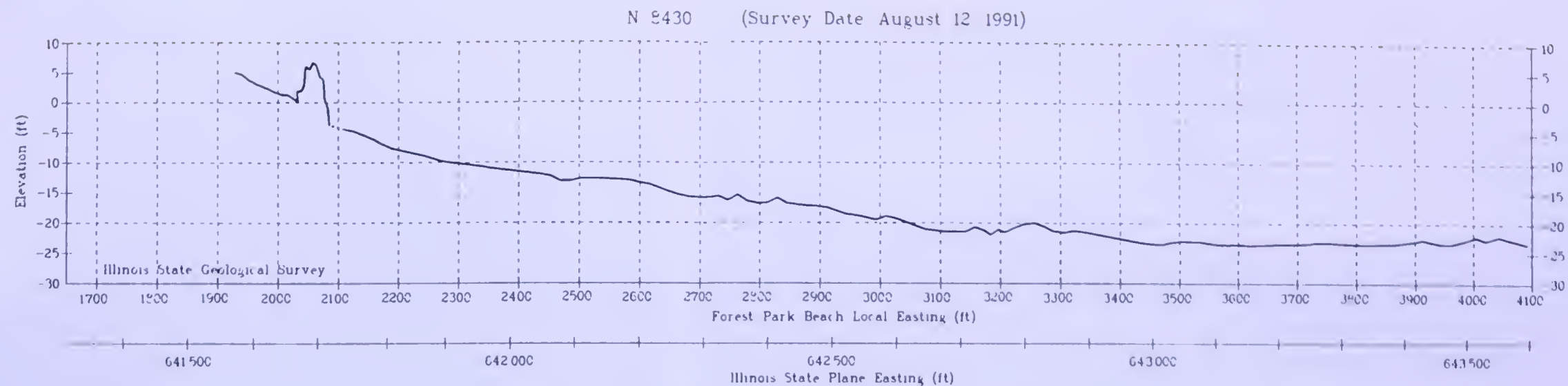


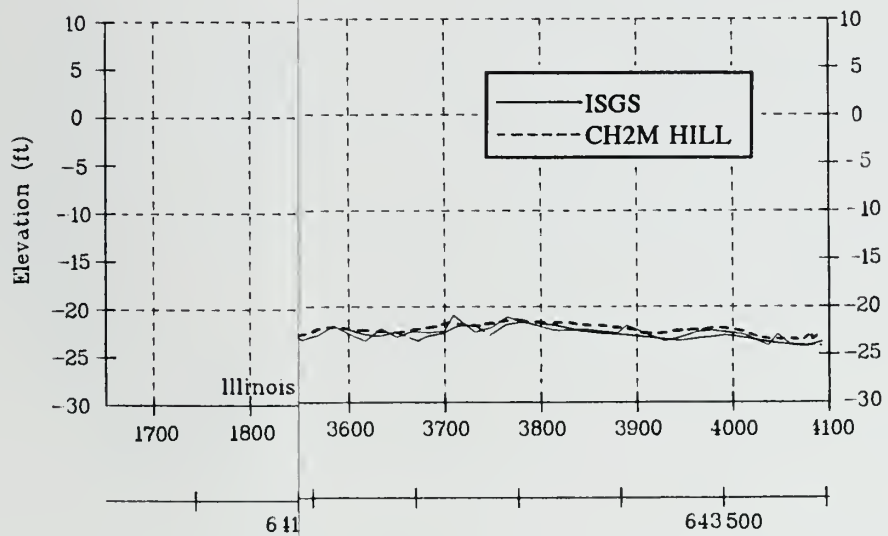
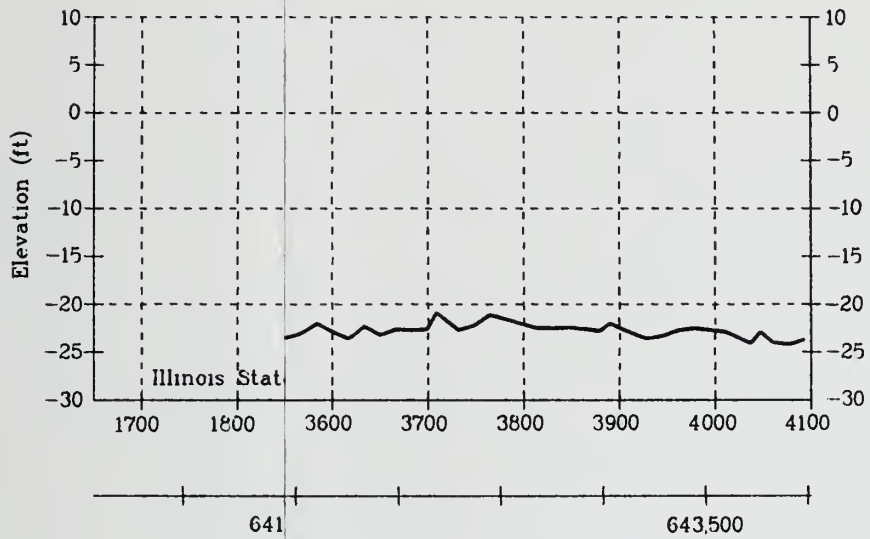
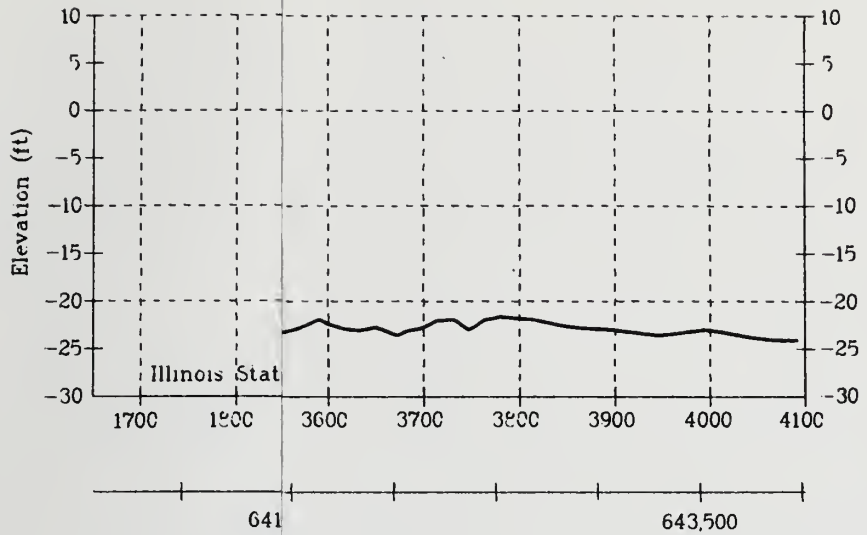
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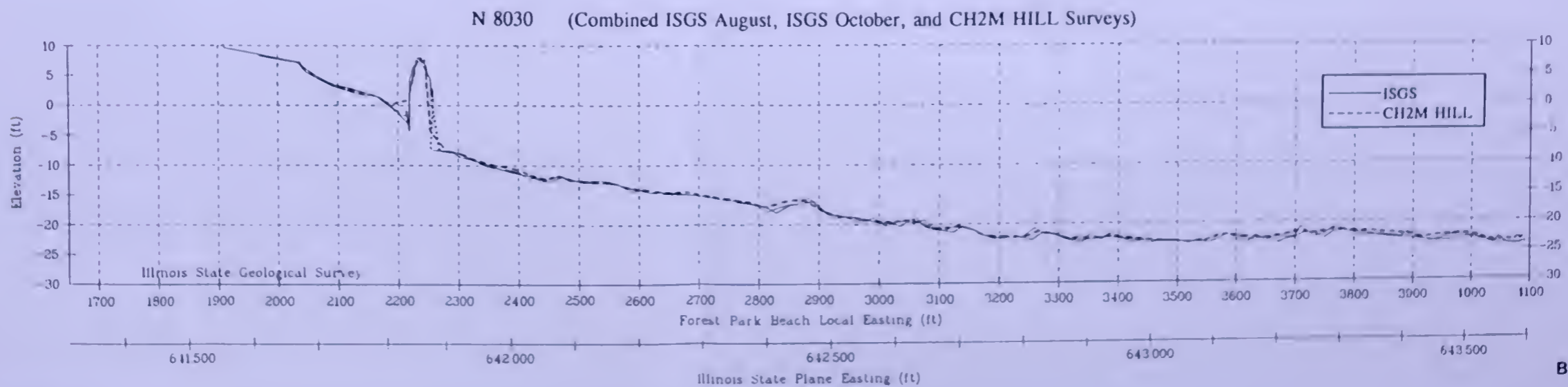
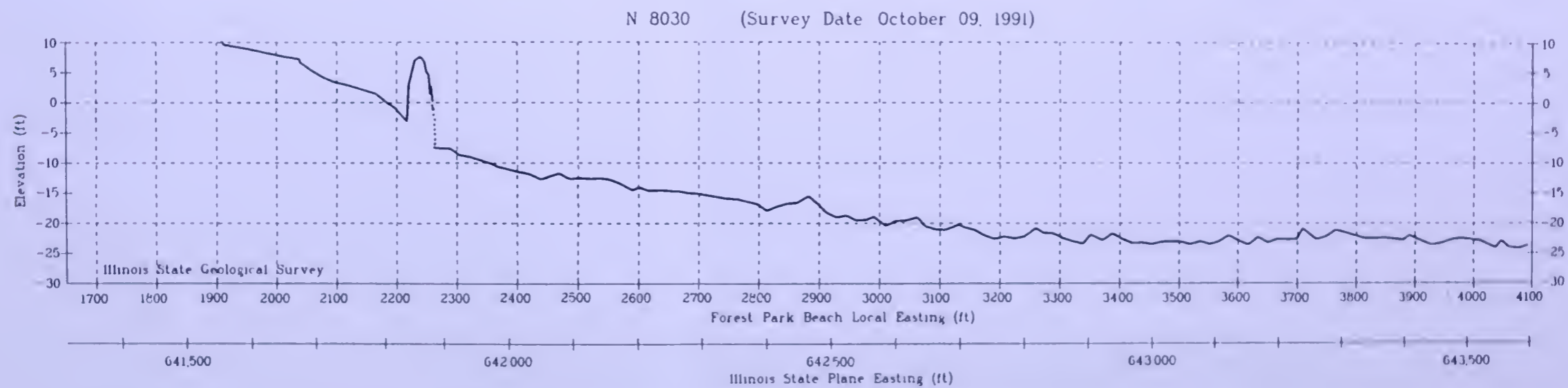
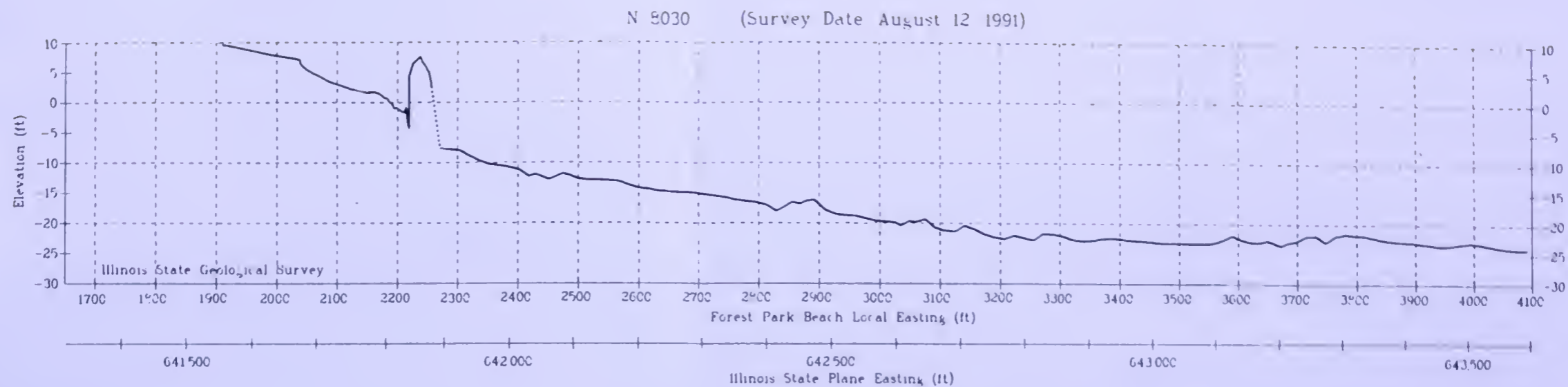
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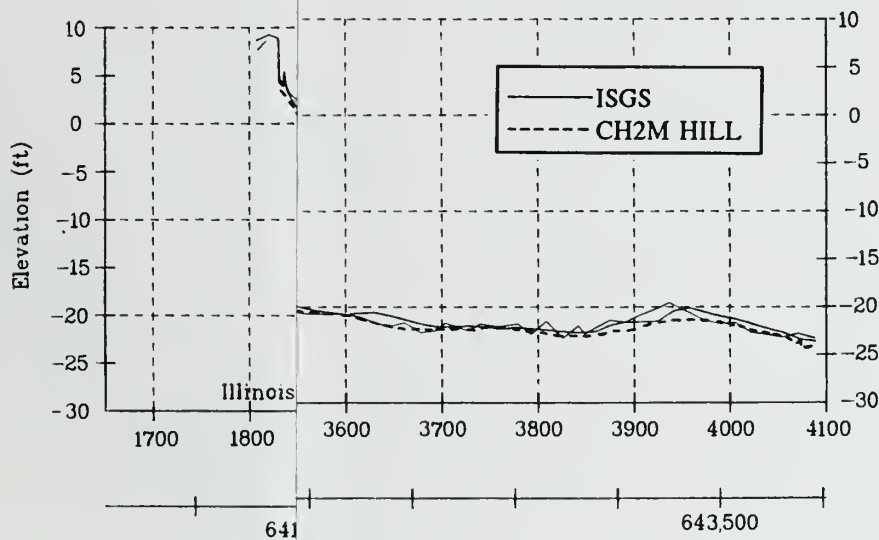
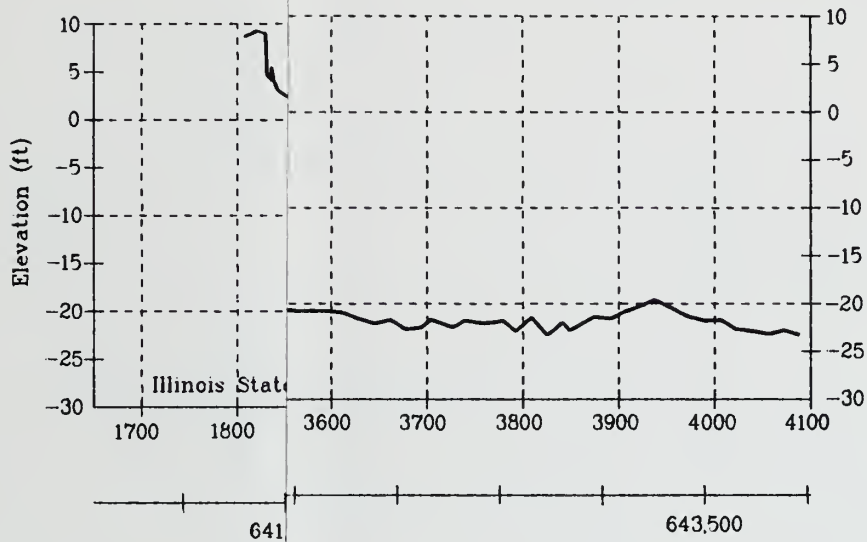
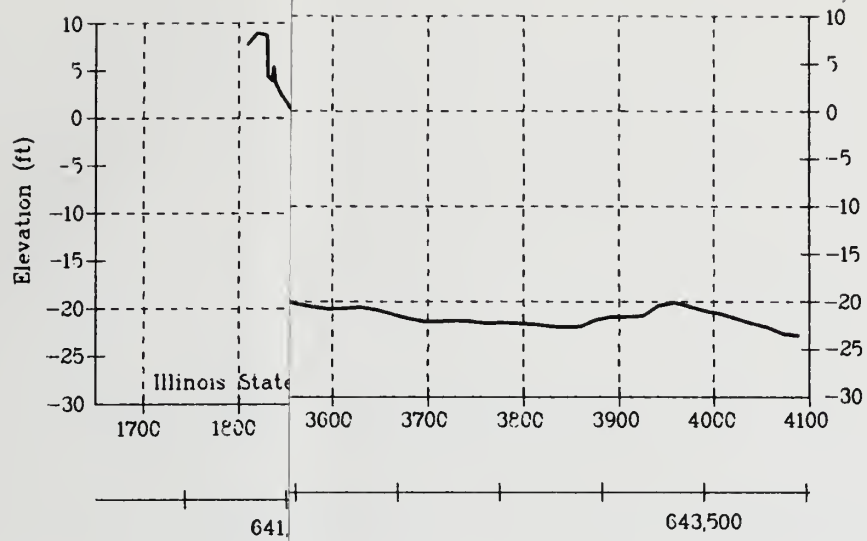


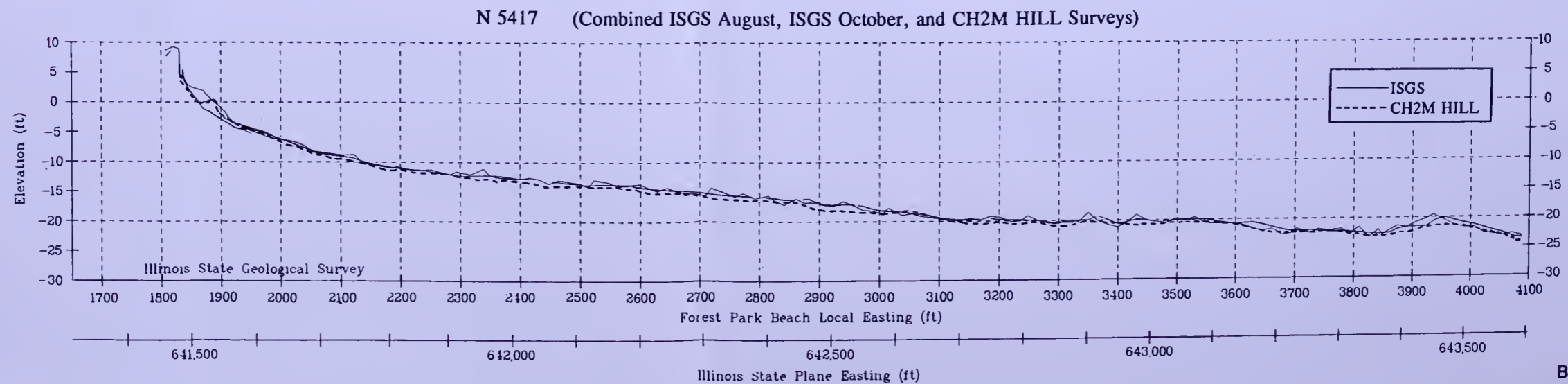
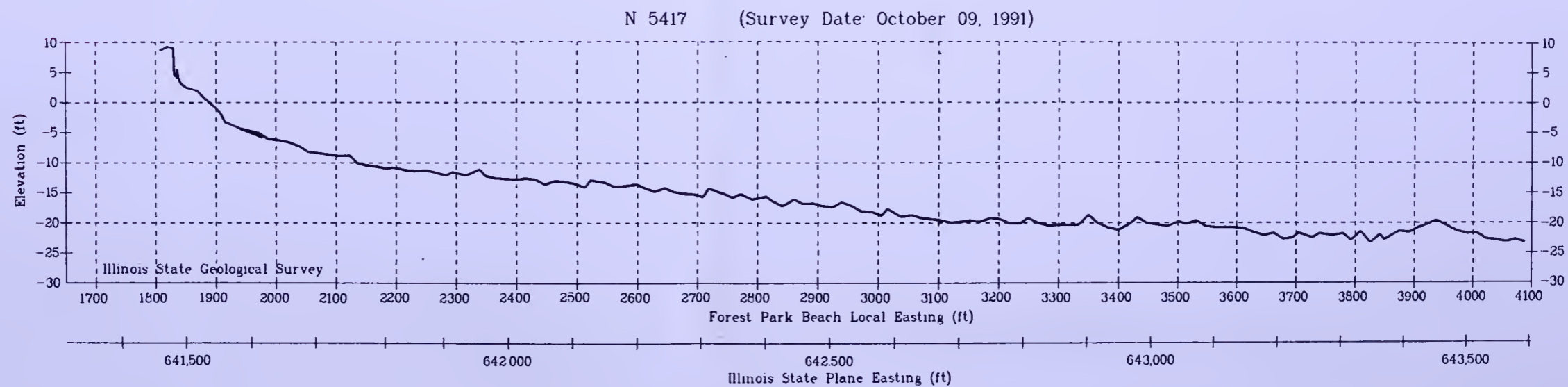
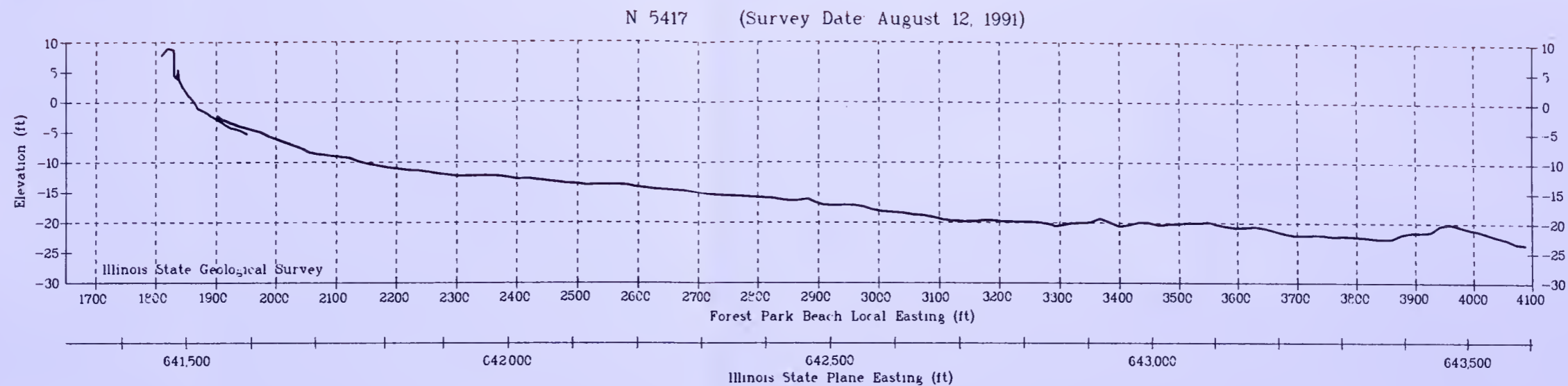


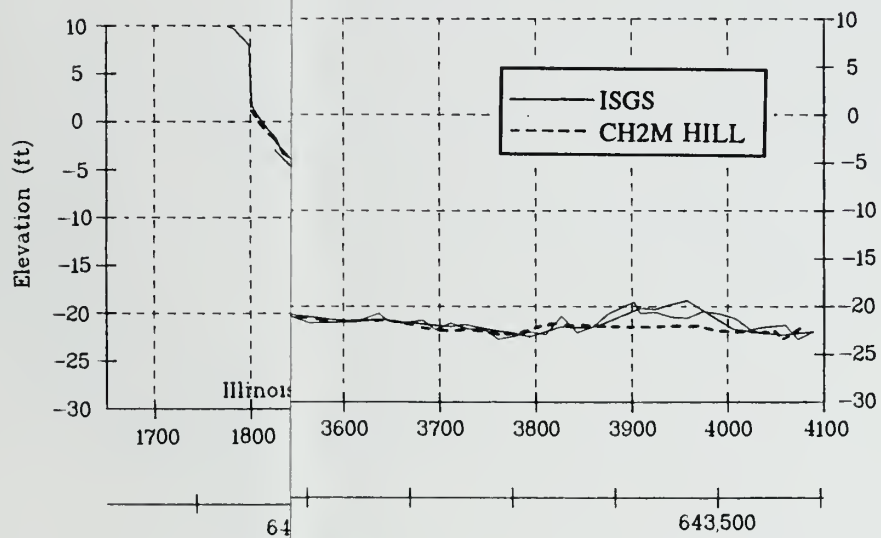
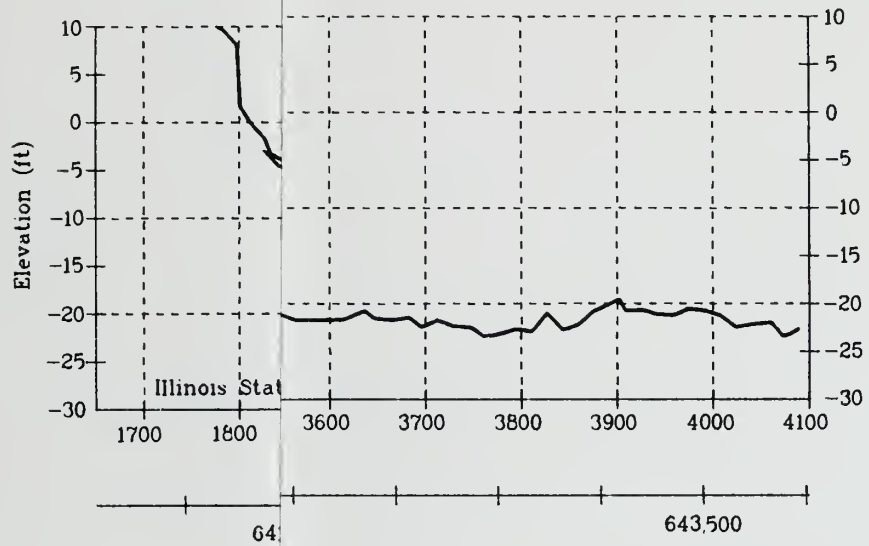
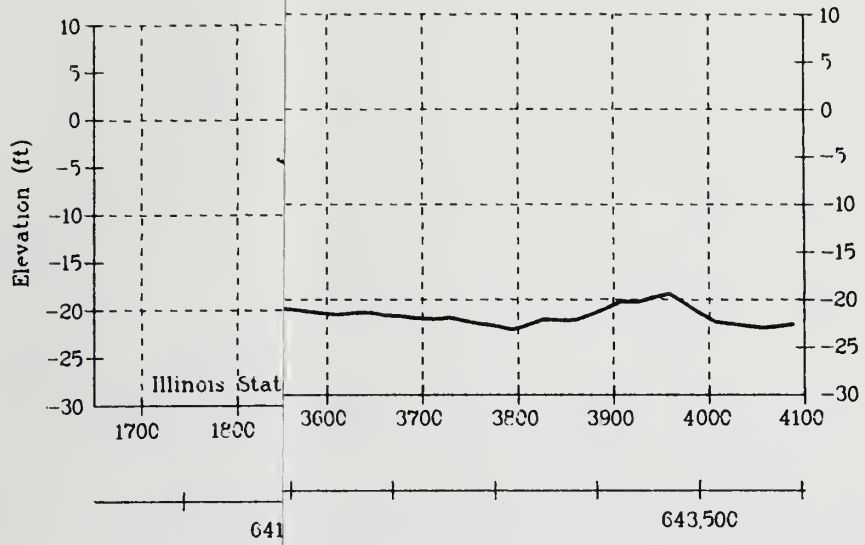




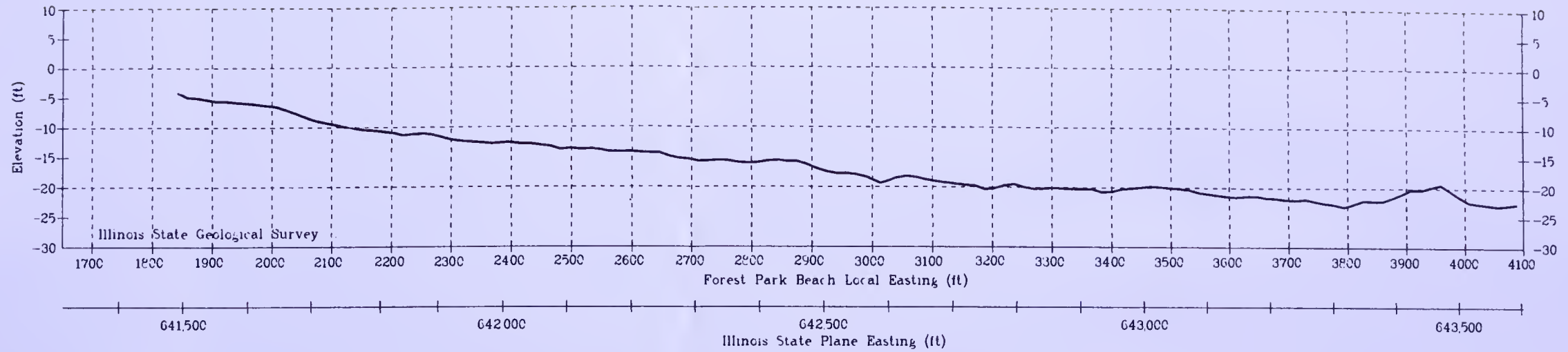




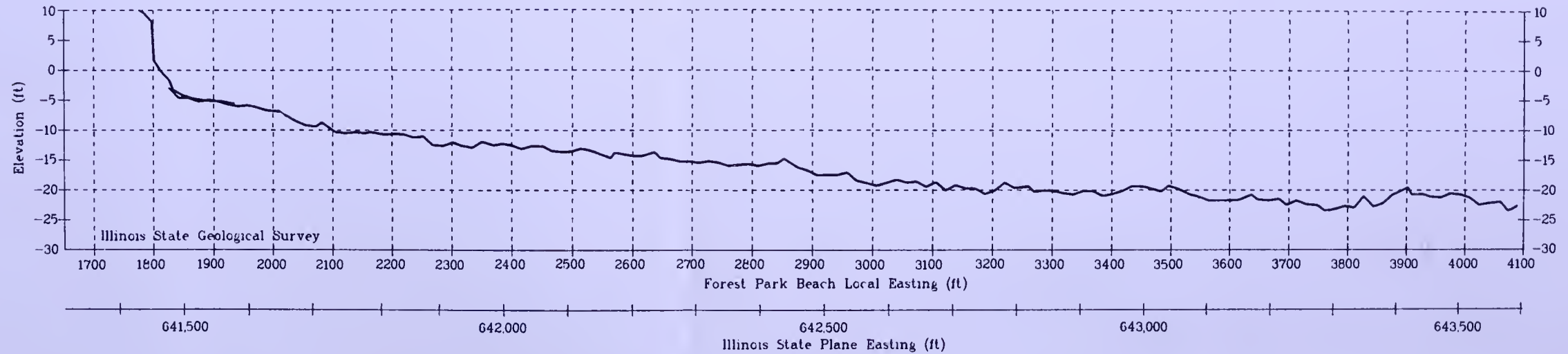




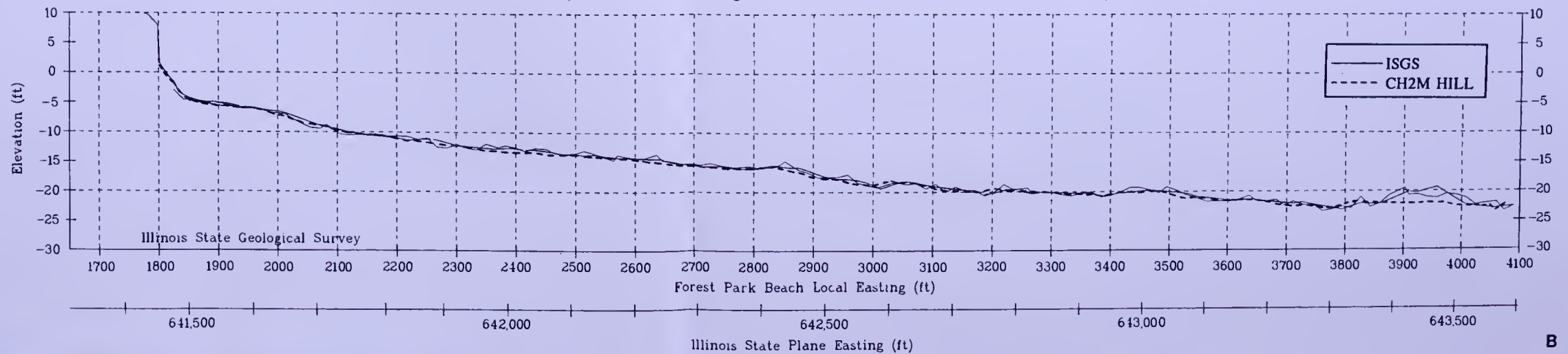
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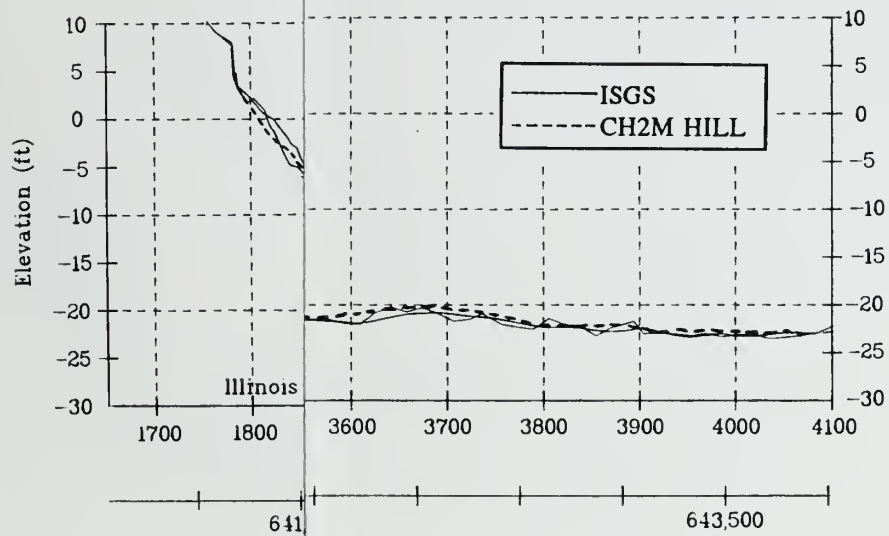
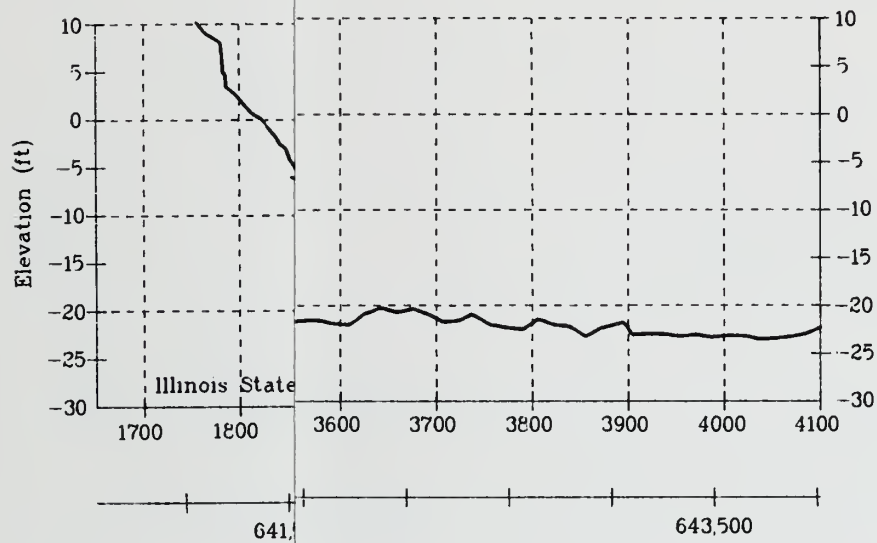
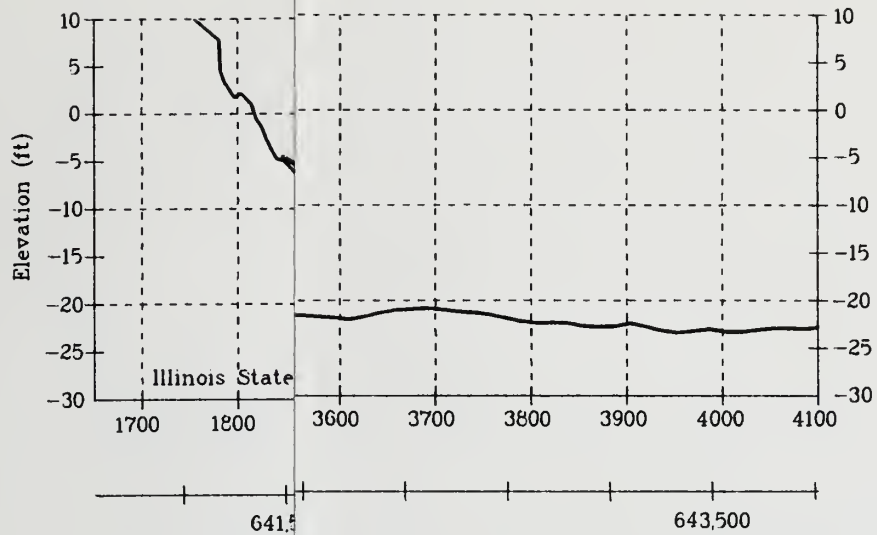


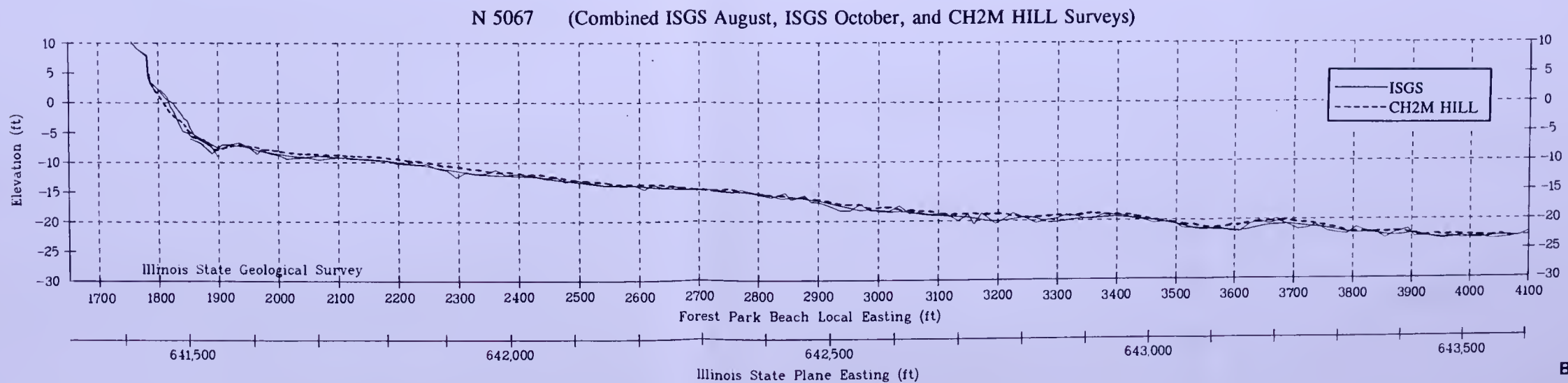
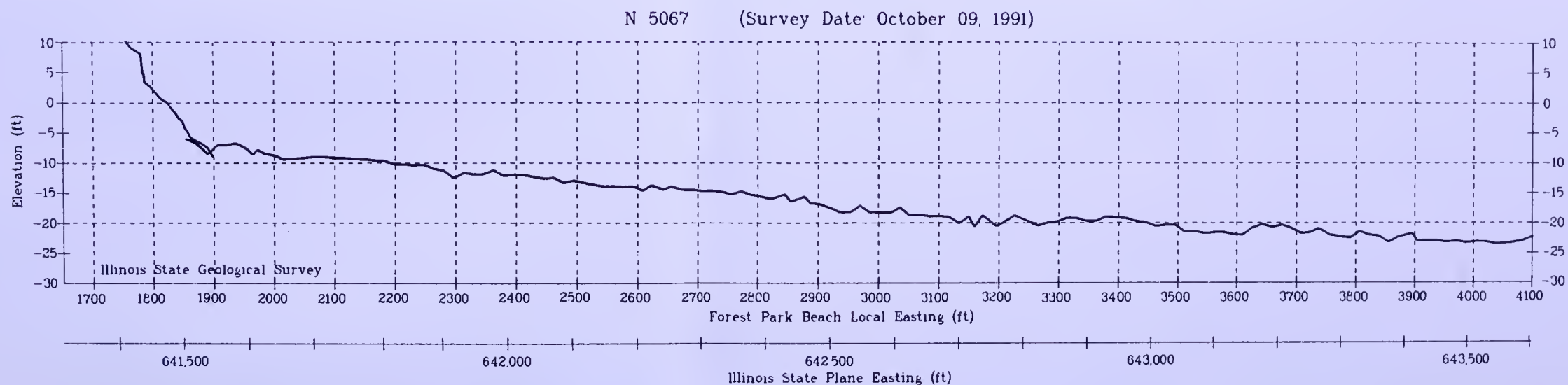
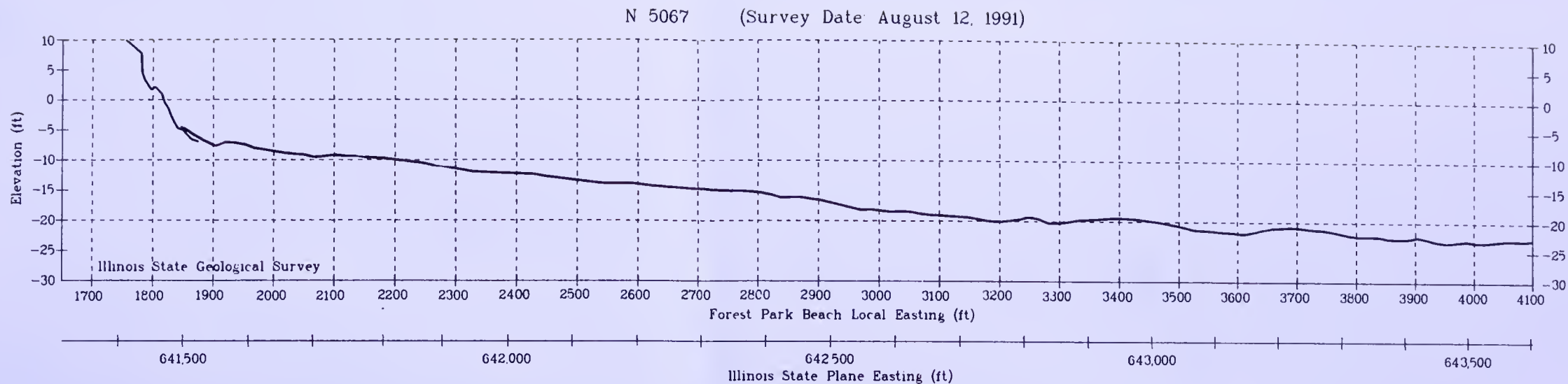
N 5267 (Survey Date October 09, 1991)

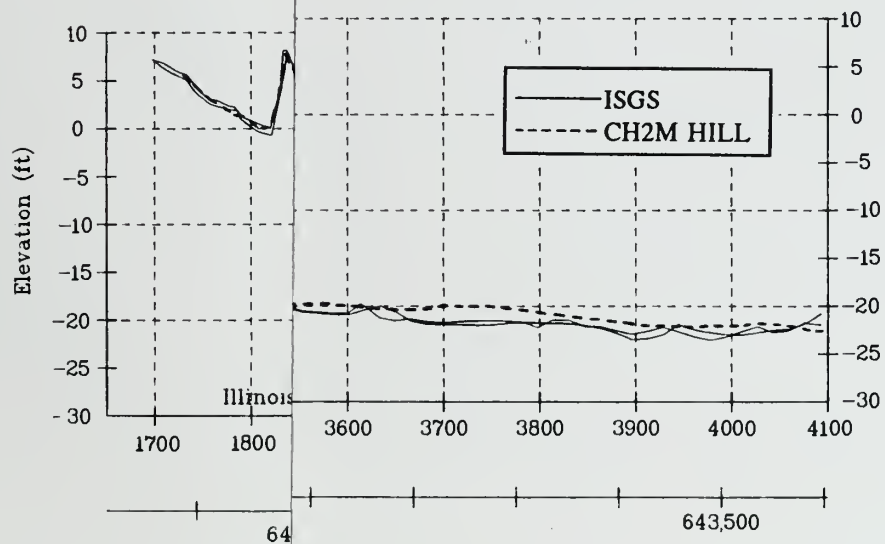
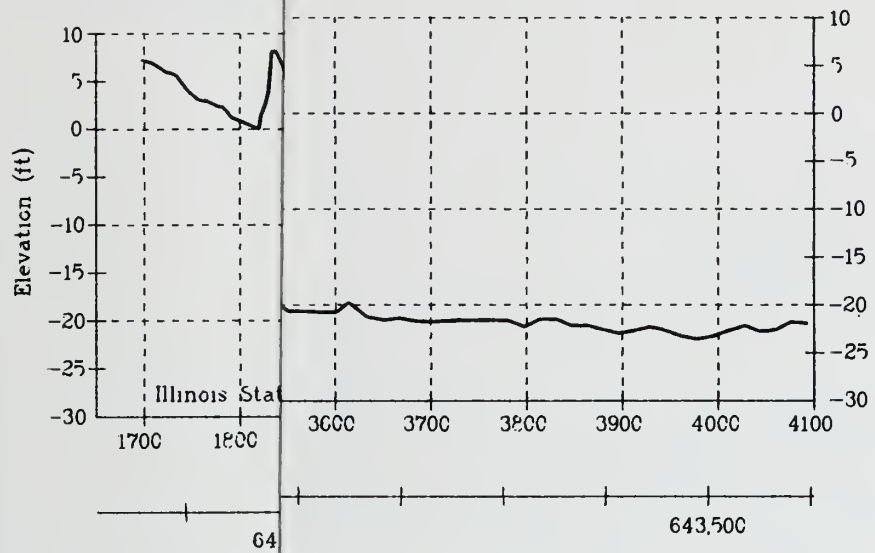
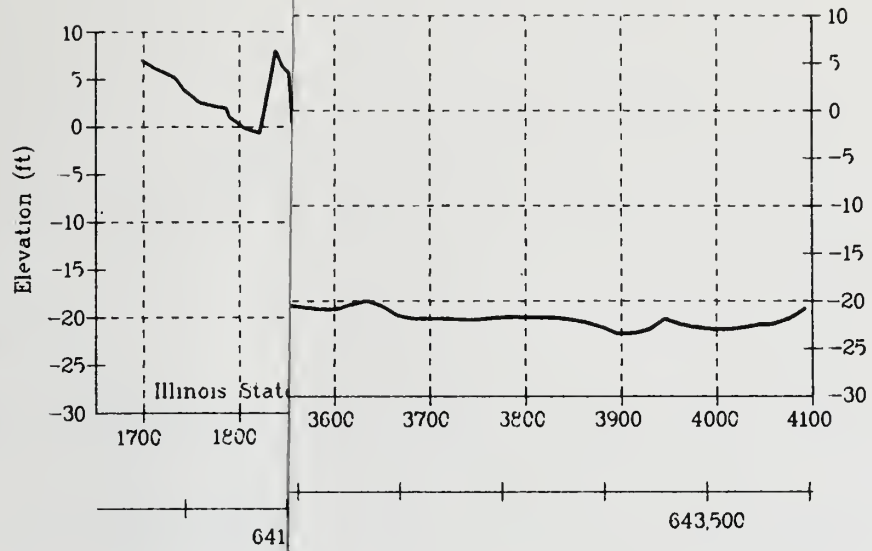


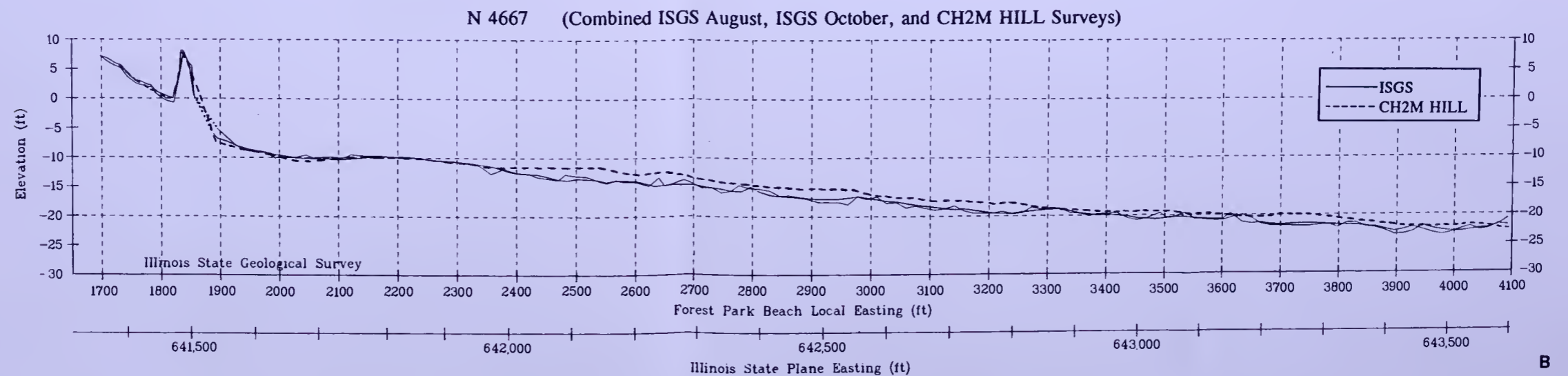
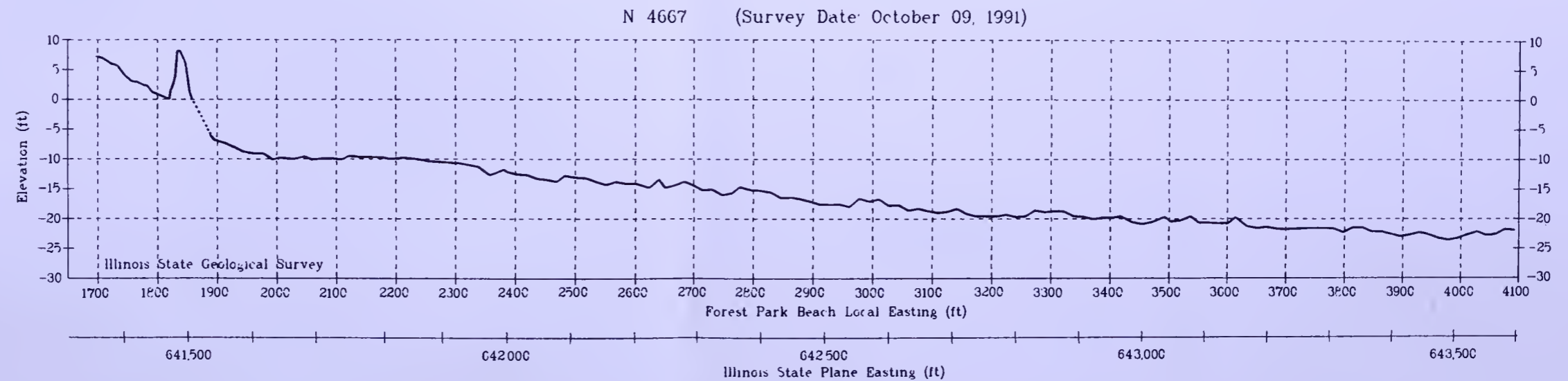
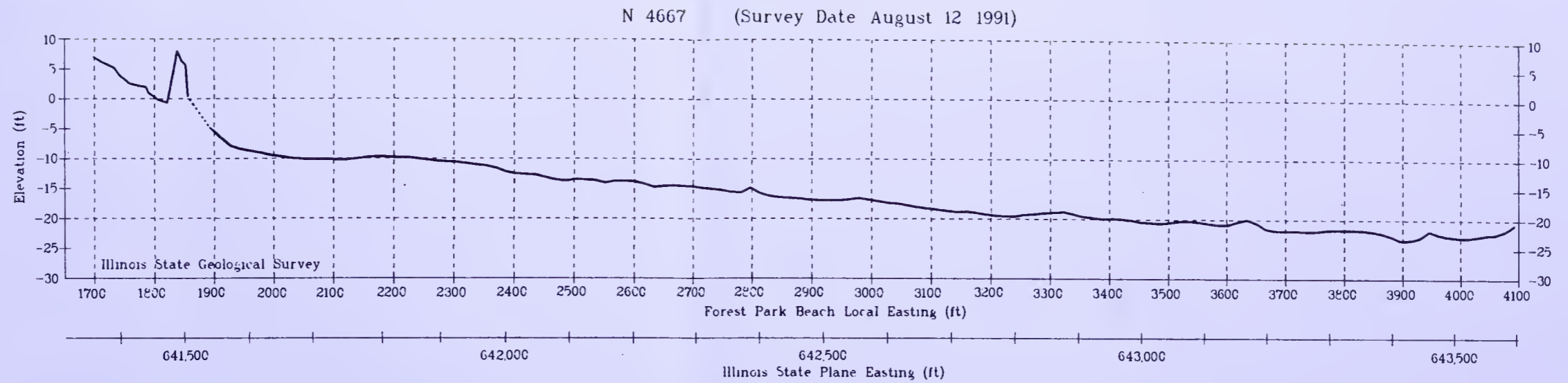
N 5267 (Combined ISGS August, ISGS October, and CH2M HILL Surveys)











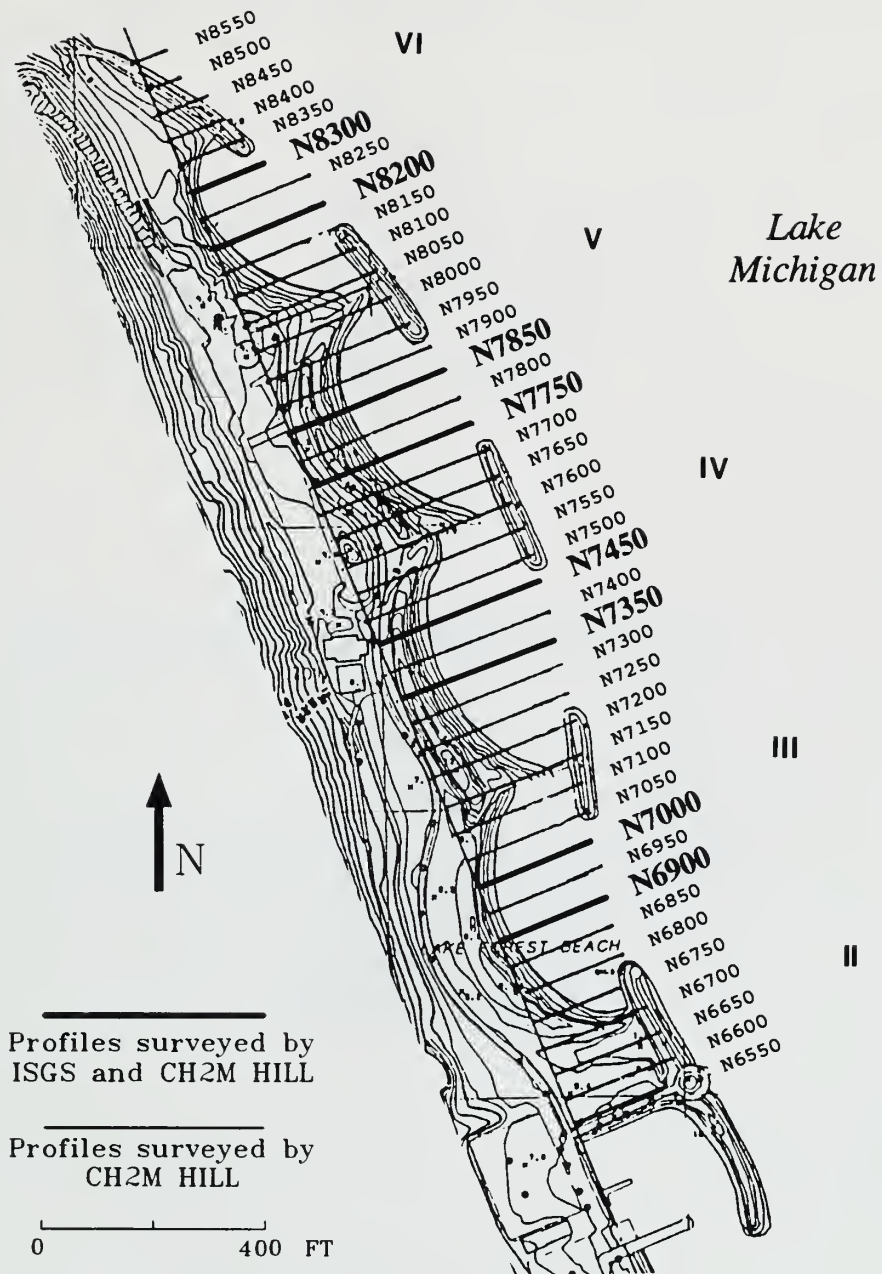
APPENDIX C

Comparison of ISGS and CH2M HILL 1991 Beach and Nearshore Wading (Short) Profiles

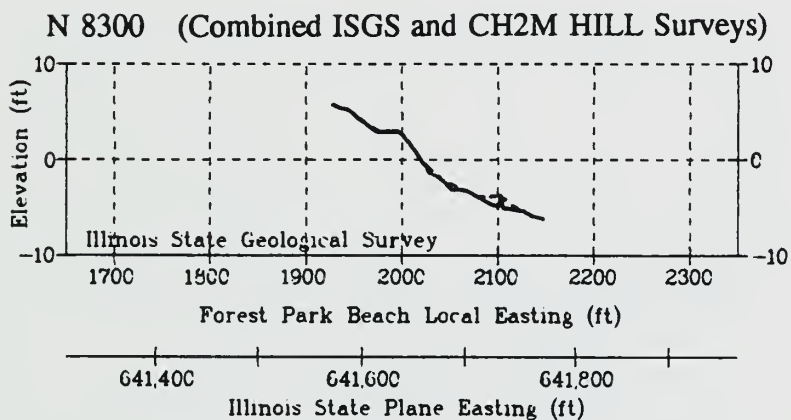
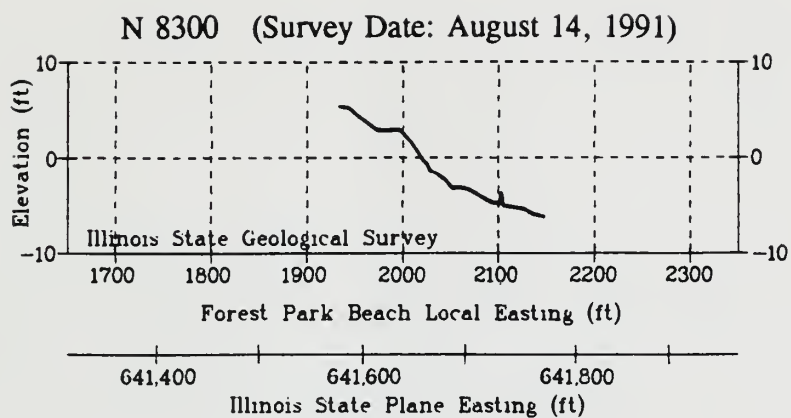
EXPLANATION

The two profiles presented in stacked arrangement are:

- A) ISGS beach and nearshore wading (short) profiles for August 12, 1991
- B) Comparison of ISGS and CH2M HILL beach and nearshore wading profiles for August 1991

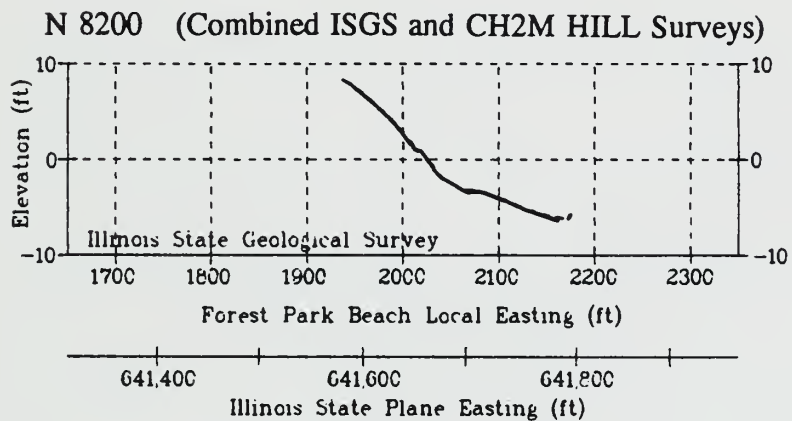
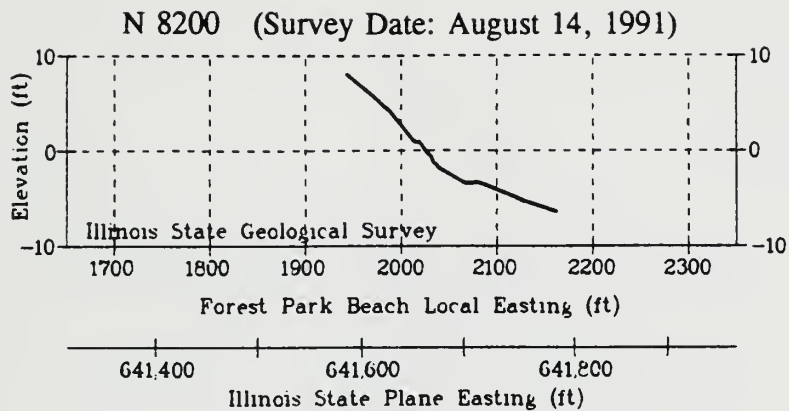


INDEX MAP
FOR APPENDIX C



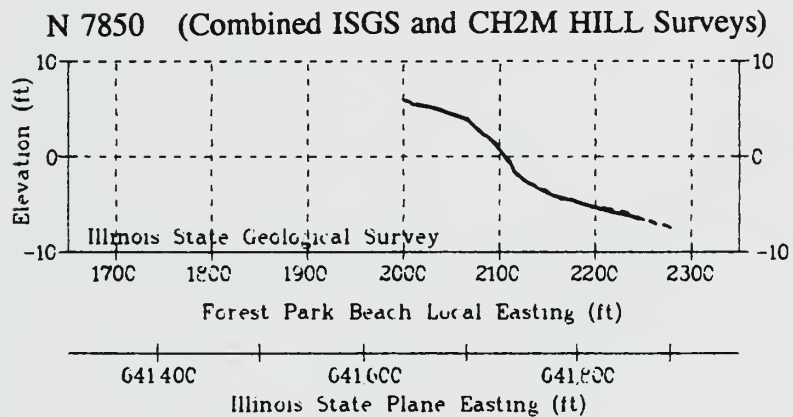
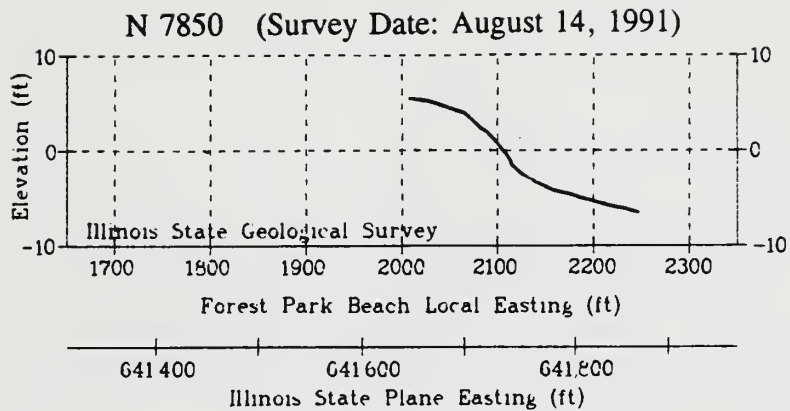
Explanation of Survey Lines

———— ISGS
 - - - - - CH2M HILL



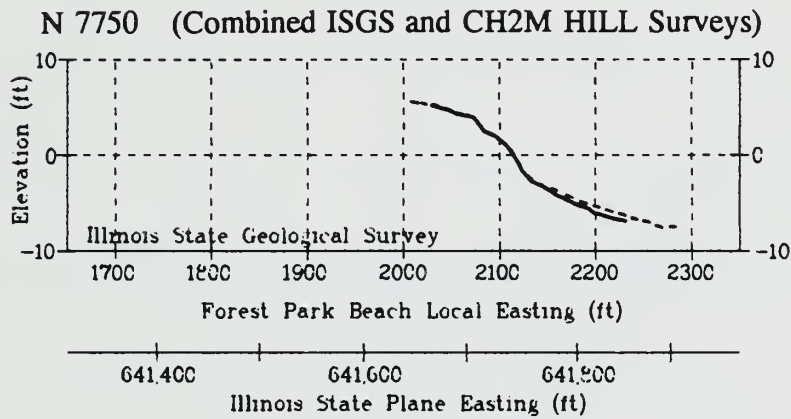
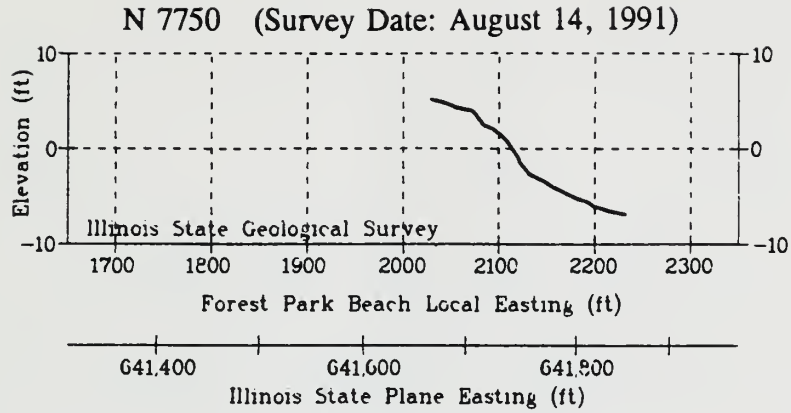
Explanation of Survey Lines

————— ISGS
 - - - - - CH2M HILL



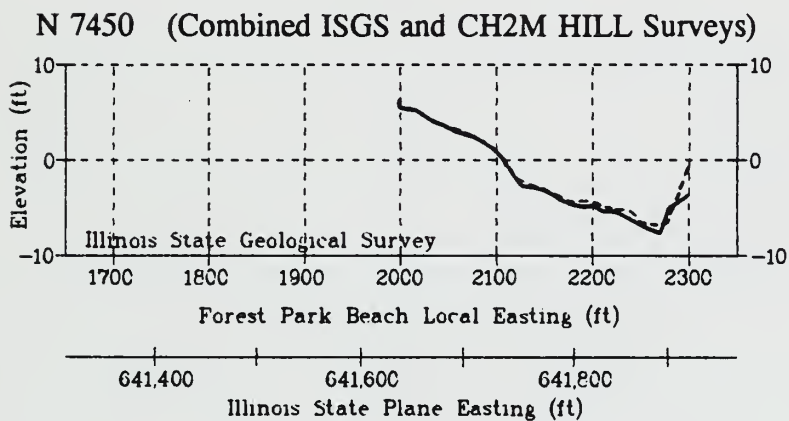
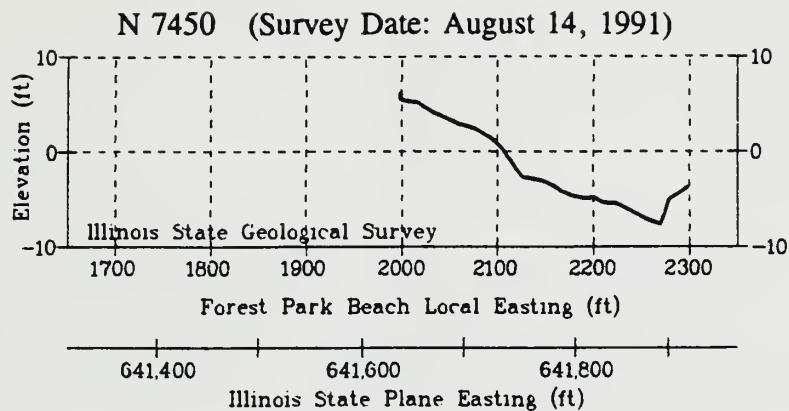
Explanation of Survey Lines

————— ISGS
 - - - - - CH2M HILL



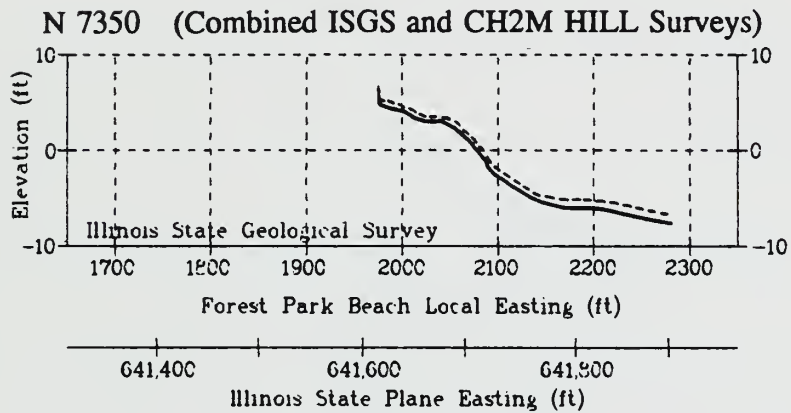
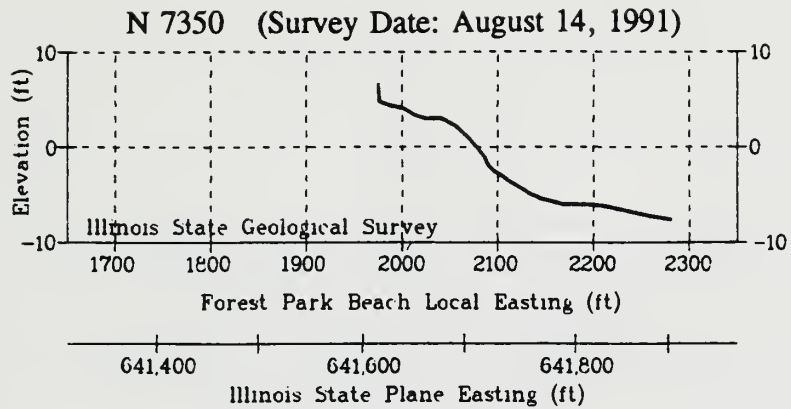
Explanation of Survey Lines

————— ISGS
 - - - - - CH2M HILL



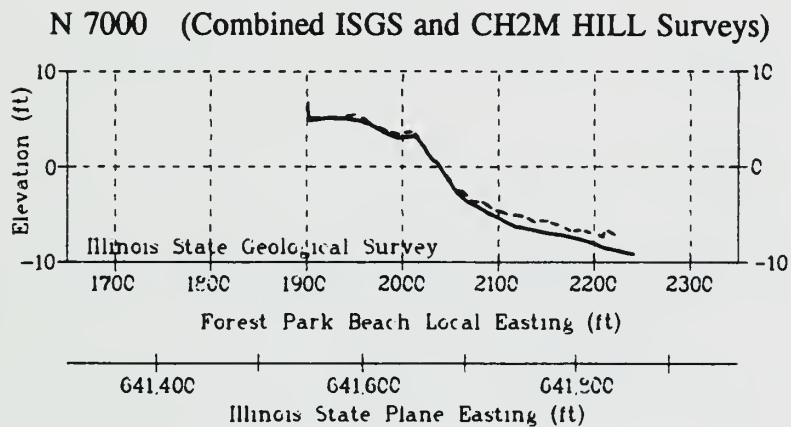
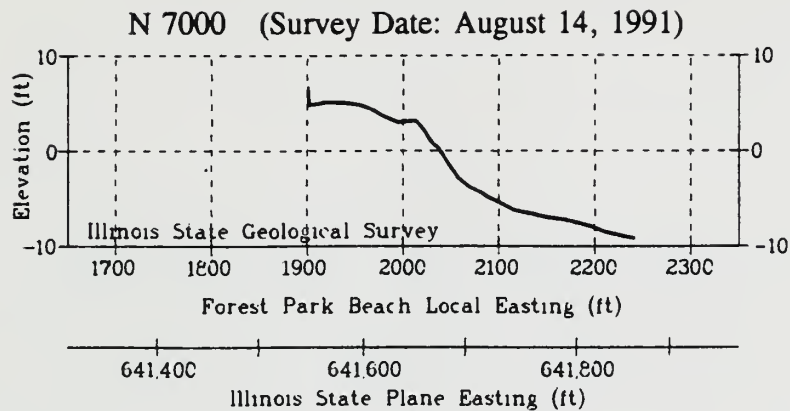
Explanation of Survey Lines

————— ISGS
 - - - - - CH2M HILL



Explanation of Survey Lines

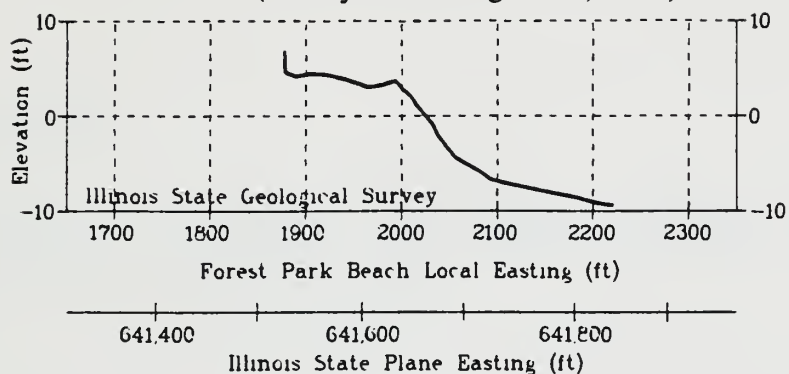
————— ISGS
 - - - - - CH2M HILL



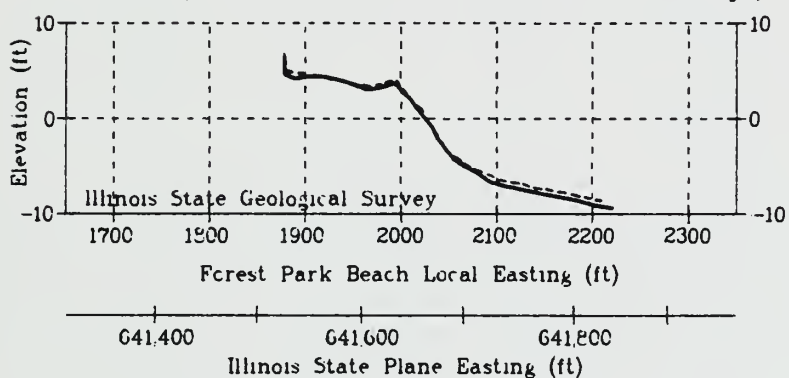
Explanation of Survey Lines

— ISGS
 - - - CH2M HILL

N 6900 (Survey Date: August 14, 1991)



N 6900 (Combined ISGS and CH2M HILL Surveys)



Explanation of Survey Lines

- ISGS
- CH2M HILL

APPENDIX D

Grain Size Analysis of 1991 Downdrift Nourishment

EXPLANATION

Results of grain size analysis of three samples collected by the ISGS from the nourishment pile on August 31, 1991. All grain size analysis performed by the ISGS Quaternary Materials Laboratory.

File: PS 9154

QUATERNARY MATERIALS LABORATORY
PARTICLE SIZE CALCULATION WORKSHEET

Sample Name NOUR-1/3 91 AUG 31

Sample weight = 137.06

Screen (phi)	Screen (mm)	Weight Retained	Weight Finer	Percent Finer
-2.50	5.657	0.00	136.84	100.00
-2.00	4.000	0.11	136.73	99.92
-1.49	2.800	1.54	135.19	98.79
-1.00	2.000	14.26	120.93	88.37
-0.49	1.400	13.70	107.23	78.36
0.00	1.000	13.18	94.05	68.73
0.49	0.710	14.68	79.37	58.00
1.00	0.500	16.86	62.51	45.68
1.49	0.355	21.01	41.50	30.33
2.00	0.250	21.44	20.06	14.66
2.47	0.180	9.70	10.36	7.57
3.00	0.125	6.36	4.00	2.92
3.47	0.090	1.87	2.13	1.56
3.99	0.063	1.06	1.07	0.78
5.00	Pan	1.07	0.00	0.00

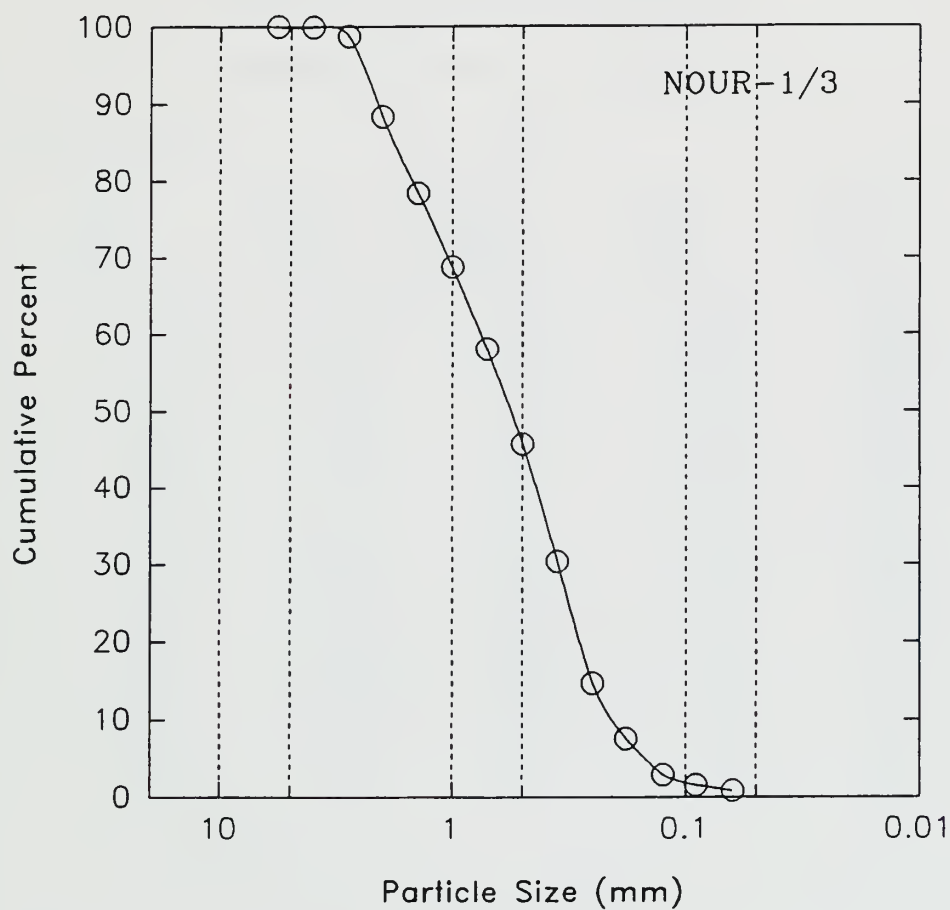
grams retained 136.84

gr loss/gain -0.22

% loss/gain -0.16

ILLINOIS STATE GEOLOGICAL SURVEY

Project: LAKE FOREST
 Sample Number: NOUR-1/3
 Date: August 31, 1991
 File: PS 9154
 Udden-Wentworth Classification: Coarse Sand



GRAVEL		SAND					SILT & CLAY
PBL	GNL	V CO	CO	MED	FINE	V FN	

File: PS 9153

QUATERNARY MATERIALS LABORATORY
PARTICLE SIZE CALCULATION WORKSHEET

Sample Name NOUR-2/3 91 AUG 31

Sample weight = 117.42

Screen (phi)	Screen (mm)	Weight Retained	Weight Finer	Percent Finer
-2.00	4.000	0.00	117.25	100.00
-1.49	2.800	1.68	115.57	98.57
-1.00	2.000	9.88	105.69	90.14
-0.49	1.400	13.39	92.30	78.72
0.00	1.000	12.58	79.72	67.99
0.49	0.710	13.34	66.38	56.61
1.00	0.500	14.61	51.77	44.15
1.49	0.355	17.61	34.16	29.13
2.00	0.250	17.69	16.47	14.05
2.47	0.180	7.64	8.83	7.53
3.00	0.125	5.28	3.55	3.03
3.47	0.090	1.65	1.90	1.62
3.99	0.063	0.94	0.96	0.82
5.00	Pan	0.96	0.00	0.00

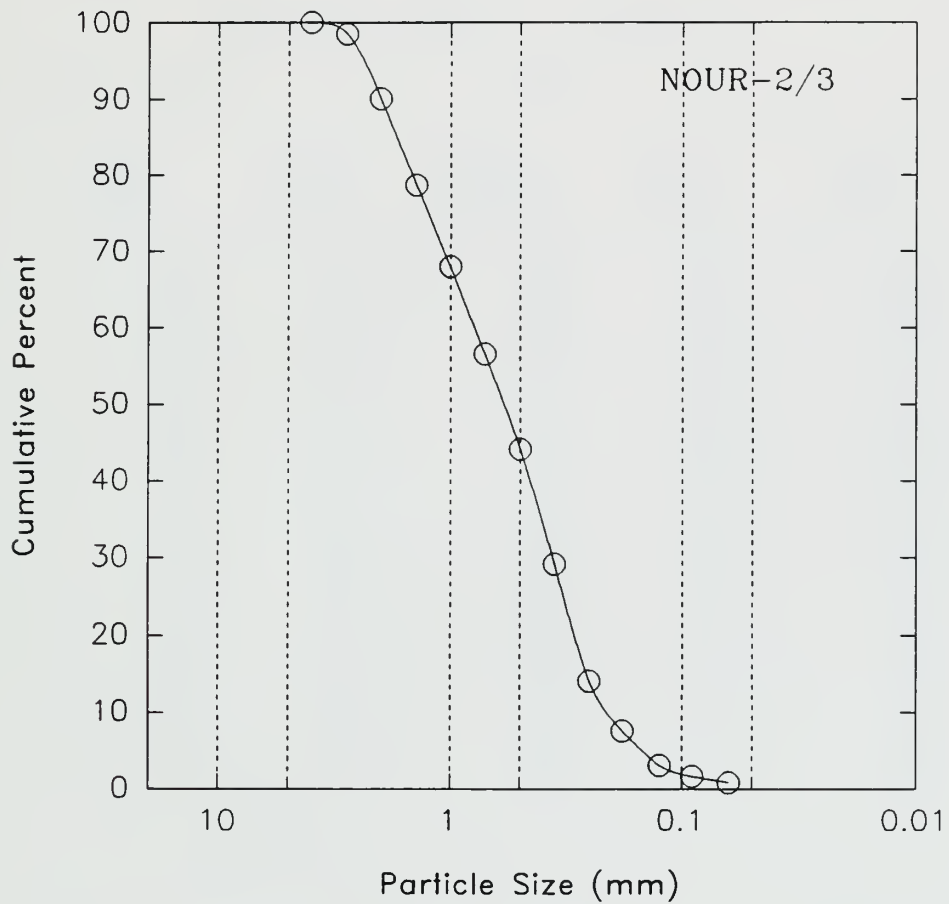
grams retained = 117.25

gr loss/gain -0.17

% loss/gain -0.14

ILLINOIS STATE GEOLOGICAL SURVEY

Project: LAKE FOREST
 Sample Number: NOUR-2/3
 Date: August 31, 1991
 File: PS 9153
 Udden-Wentworth Classification: Coarse Sand



GRAVEL		SAND					SILT & CLAY
PBL	GNL	V CO	CO	MED	FINE	V FN	

File: PS 9152

QUATERNARY MATERIALS LABORATORY
PARTICLE SIZE CALCULATION WORKSHEET

Sample Name NOUR-3/3 91 AUG 31

Sample weight = 134.68

Screen (phi)	Screen (mm)	Weight Retained	Weight Finer	Percent Finer
-2.50	5.657	0.00	134.34	100.00
-2.00	4.000	0.90	133.44	99.33
-1.49	2.800	0.84	132.60	98.70
-1.00	2.000	13.02	119.58	89.01
-0.49	1.400	19.17	100.41	74.74
0.00	1.000	16.14	84.27	62.73
0.49	0.710	16.20	68.07	50.67
1.00	0.500	15.44	52.63	39.18
1.49	0.355	18.56	34.07	25.36
2.00	0.250	17.48	16.59	12.35
2.47	0.180	7.28	9.31	6.93
3.00	0.125	5.00	4.31	3.21
3.47	0.090	1.65	2.66	1.98
3.99	0.063	1.03	1.63	1.21
5.00	Pan	1.63	0.00	0.00

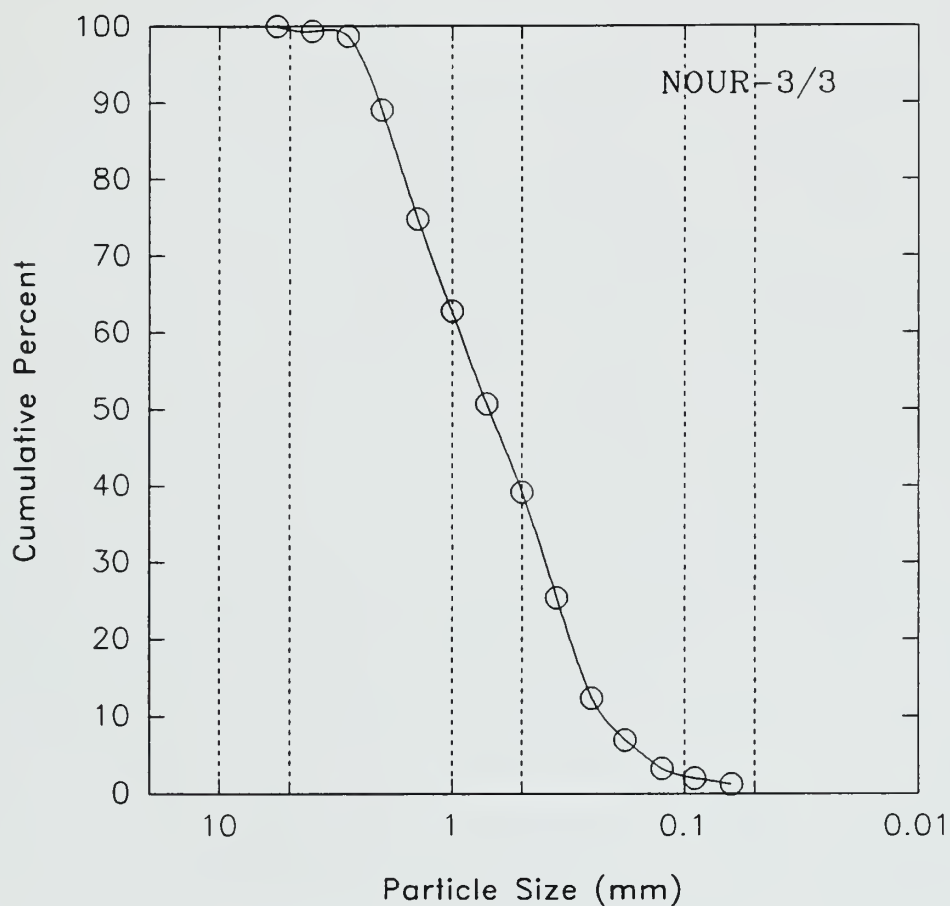
grams retained 134.34

gr loss/gain -0.34

% loss/gain -0.25

ILLINOIS STATE GEOLOGICAL SURVEY

Project: LAKE FOREST
 Sample Number: NOUR-3/3
 Date: August 31, 1991
 File: PS 9152
 Udden-Wentworth Classification: Coarse Sand



GRAVEL		SAND					SILT & CLAY
PBL	GNL	V CO	CO	MED	FINE	V FN	

